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K. G. Squires
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7. Abstract

The purpose of the Sine pump feature test was to determine the applicability of the Sine pump as a conveying method for transporting single-shell tank waste. The Sine pump is a fairly new type of pump only used in the food industry. It pumps both types of simulant with ease. The 1.7 million cp and a high percentage of solid simulant cannot be pumped by any other positive displacement pump presently in production. The real concern with the pump is in the software parts which are designed to wear out. The software parts did wear and production dropped off drastically. This protects the remainder of the pump from completely failing. These parts are made of elastomers and would need to be changed to materials that would survive in our application. The test showed that the Sine pump would work but will require redesign of all the software components of the pump to work in our application. The Sine pump was designed in such a way that it will be easily made to be remotely repaired and worked on. This pump should be considered if a positive displacement pump is to be used in the program.

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FEATURE TEST OF THE SINE PUMP

K. G. Squires

September 1990

CONTENTS

1.0 INTRODUCTION

The feature testing of the Sine[1] pump was one of several tests called for by the *Single-Shell Tank Feature Testing Test Plan* (Thompson 1990). The work was contracted to Beckwith and Kuffel Inc. who provided the equipment, facilities, and personnel for the testing under contract number MBH-SVV-072554. The actual testing occurred from August 27-31, 1990.

The objective of the feature testing program is to complement the *Single-Shell Tank Waste Retrieval Study* (Krieg, et al. 1990) in recommending technologies for further development as part of the *Hanford Federal Facility Agreement and Consent Order*, known as the Tri-Party Agreement (Ecology et al. 1989) Milestone M-06-00. The Sine pump feature test was to evaluate "off-the-shelf" technology for waste transfer. The Sine pump is one of the possible methods to be used to transfer chemical wastes from within the tanks to the surface. The pump was tried on two types of sludge simulants to evaluate its capabilities.

2.0 DESCRIPTION OF TEST

The purpose of the feature test was to evaluate the Sine pump as a conveying method for the single-shell tank retrieval program.

Pump Model: Sine[1] SPS-50
Pump Driver: direct coupled 37 BHP DC variable speed electric motor
Maximum Pressure: 150 psig
Maximum Temperature: 230 F
Maximum Flow Rate: 300 gpm

The Sine pump consists of a sinusoidal rotor, scrapergate, liner, and pump housing (see Figure 1). The rotor is a sinusoidal "impeller" in which two complete sine curves create four separate, symmetrical pumping compartments. As the rotor turns in the pump housing, the compartments travel through the liners, which provide a positive displacement of liquid from the suction to discharge port. The sliding scraper gate prevents the product from going past the discharge, back to the suction side of the pump. The high points of the sine curve are always in contact or are near the liners and scraper gate. The liners (front and back) surround the rotor inside the pump housing, except at the discharge and suction ports.

The Sine pump components are divided into two types. The first is the hardware components which are the pump housing, pump cover, pump rotor, pump shaft and pump bearings. The hardware components are designed to last the

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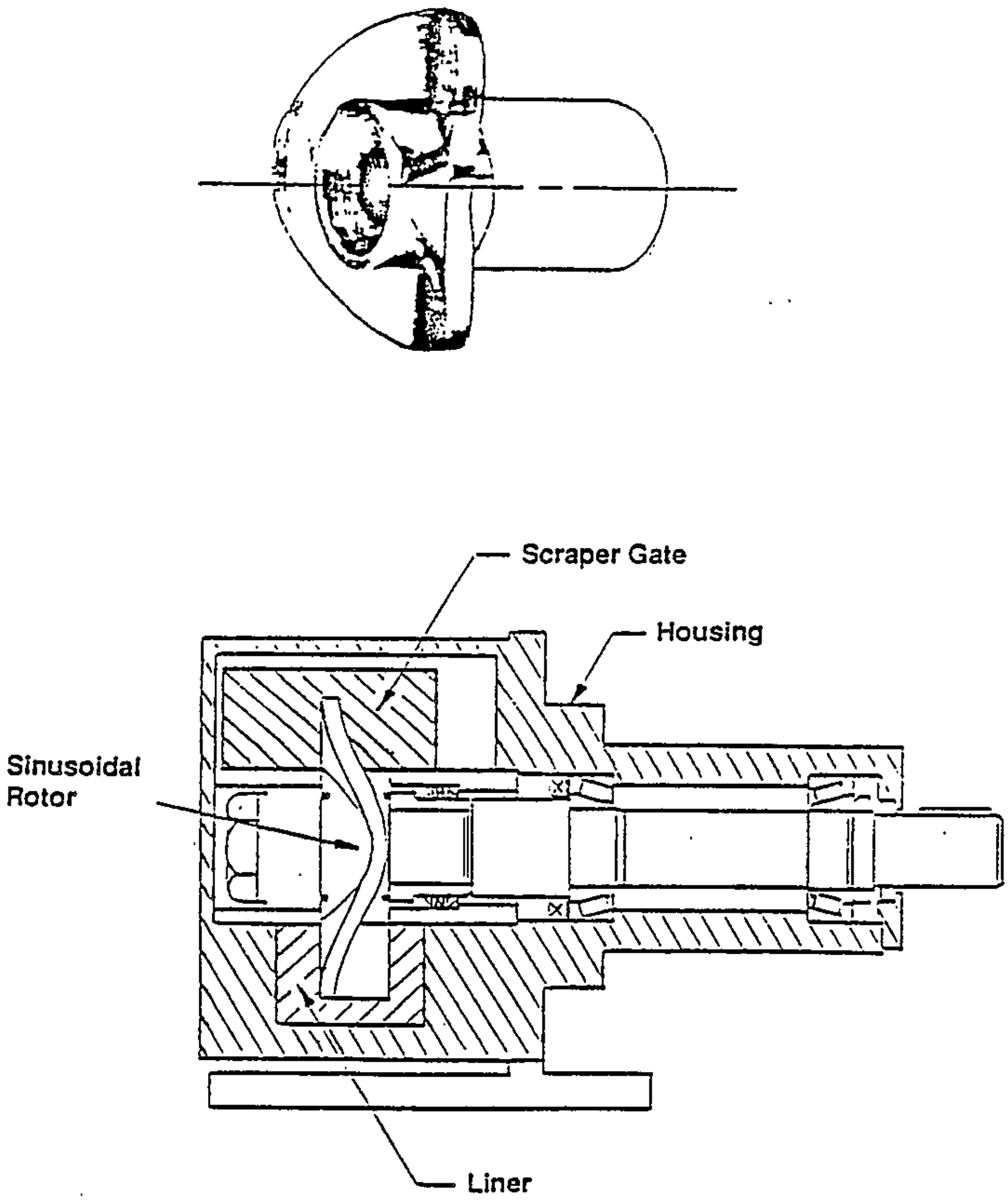
1. Sine is a Trademark of Sine Pump, Orange, Massachusetts

Figure 1. Sine Pump



life or nearly the life of the pump. The other type is the software components which include the scrapergate, scrapergate support housing, shaft seal, inner liner, and the outer liner. The software components are designed to wear out, are easily replaced, and protect the hardware components from damage.

3.0 TEST METHOD AND TEST EQUIPMENT

The testing used two different simulants for the Sine pump feature test. The two simulants should cover the range of the dislodged chemical wastes. The thick simulant (A) is comparable to peanut butter while the thin simulant (B) is comparable to the typical sun tan lotion. The simulants have the following properties:

	BULK DENSITY (g/ml)	VISCOSITY (cp)
Simulant A	1.6	1,700,000
Simulant B	1.3	40

The simulant was loaded into the test loop hopper (see Figure 2). The simulant was then pumped in a recirculating fashion until the desired test parameters were obtained. The testing was divided into two sections: the first was the RPM testing and the second was the suction head testing.

The first test, RPM testing, varied the RPM in 50 RPM intervals and recorded motor voltage, motor amperage, line pressure (which if possible was fixed at 125 psig), temperature of the simulant, duration of simulant transfer, and quantity of simulant transferred.

The second test, suction head testing, fixed the RPM of the pump and the line pressure (125 psig) and varied the suction control valve from 0 psig to -10 psig in 2 psig steps. The data recorded during the test were the same as the RPM test but the suction pressure reading was also recorded.

During all the testing the pump components that were defined by the manufacturer as expendable were monitored and measured. The worn components were replaced to attempt to maintain the pump on an acceptable performance level.

A list of all instruments and equipment used is in the Appendix, Section 2.

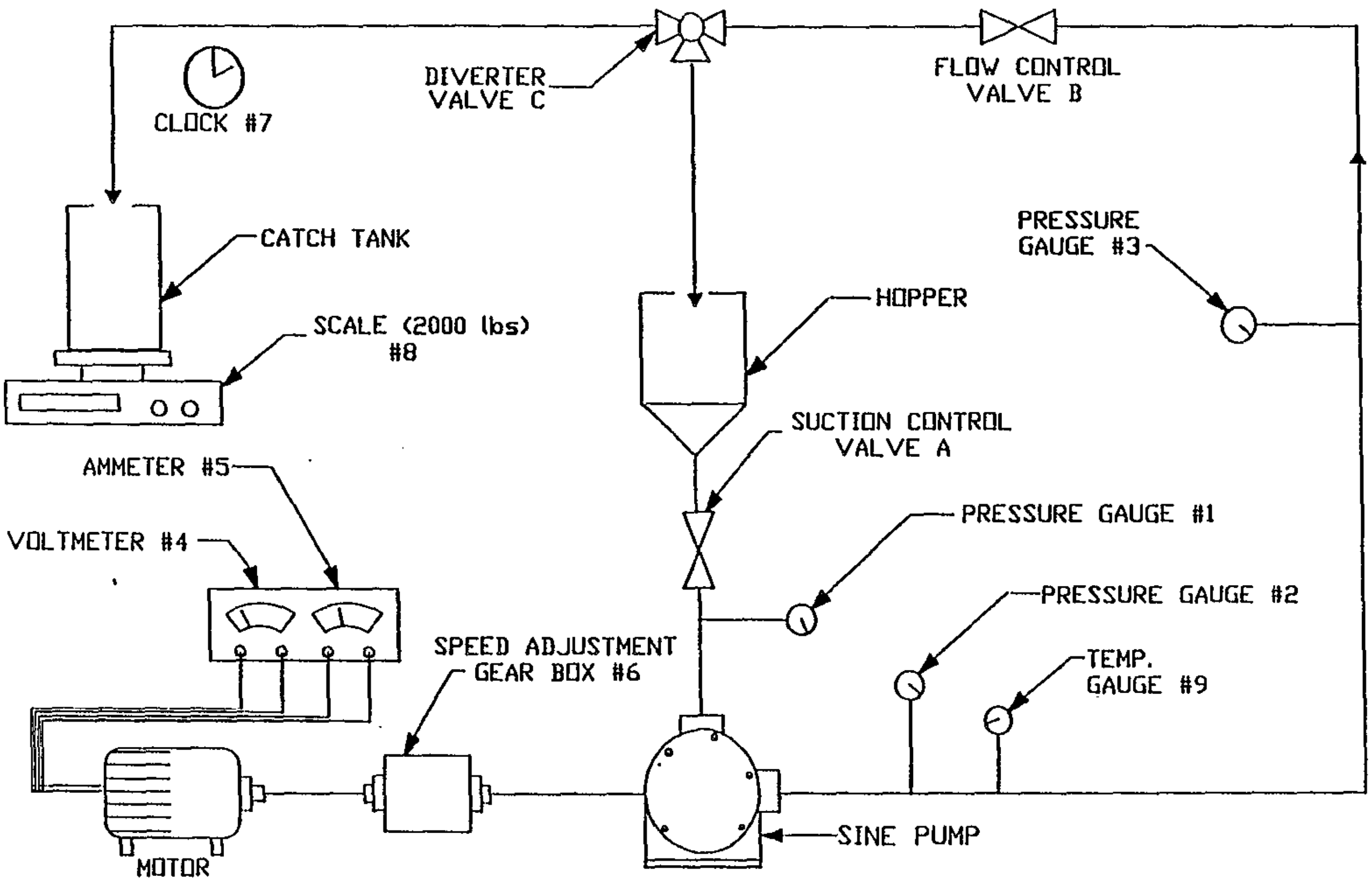


Figure 2. Test Loop for Sine Pump Feature Testing.

4.0 TEST RESULTS

The test results of the RPM test for both simulants shows that the pump is capable of meeting the required pressure and flow rates (see Figures 3 and 4). The variation between data runs shows that the condition of the software components have a significant impact on the performance.

Simulant B, when ran at low RPMs with no line pressure, approaches the vendor supplied performance curve for the pump (see Figure 4). The curve is based on no line pressure using water as a fluid (see the Appendix, Section 2).

The suction head test result for A and B simulants shows good consistency but the condition of the software affects the GPM pumped (see Figures 5 and 6). This test proves that the pump has the capabilities to pull high viscosity and a high percentage of solid materials into the pump.

The A simulant acted more like a lubricant and did not cause significant wear on the pump components. The software components showed wear in the range of .006 in. per run.

The B simulant acted like an abrasive. The solids tried to imbed themselves into the software component and turned the smooth sliding surfaces into sandpaper which caused wear to all the pump components. The software components showed wear in the range of .2 in. per run. Simulant B was run first in the testing program and the wear to the pump impacted the results of the a simulant A tests.

The Appendix contains the testing data compiled by Beckwith and Kuffel for the feature test of the Sine pump.

The Sine pump operated significantly better when pumping simulant A than simulant B.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The Sine pump can produce desired flow rates, suction, and discharge pressures. The pump can pump material that most positive displacement pumps consider non-pumpable. The pump's major drawback is that the software components showed rapid wear and are made from elastomers. These parts will require some development work to come up with materials that will work in the retrieval environment and significantly increase the part life. If this can be done then the Sine pump should be considered if the single-shell tank retrieval program requires a positive displacement pump.

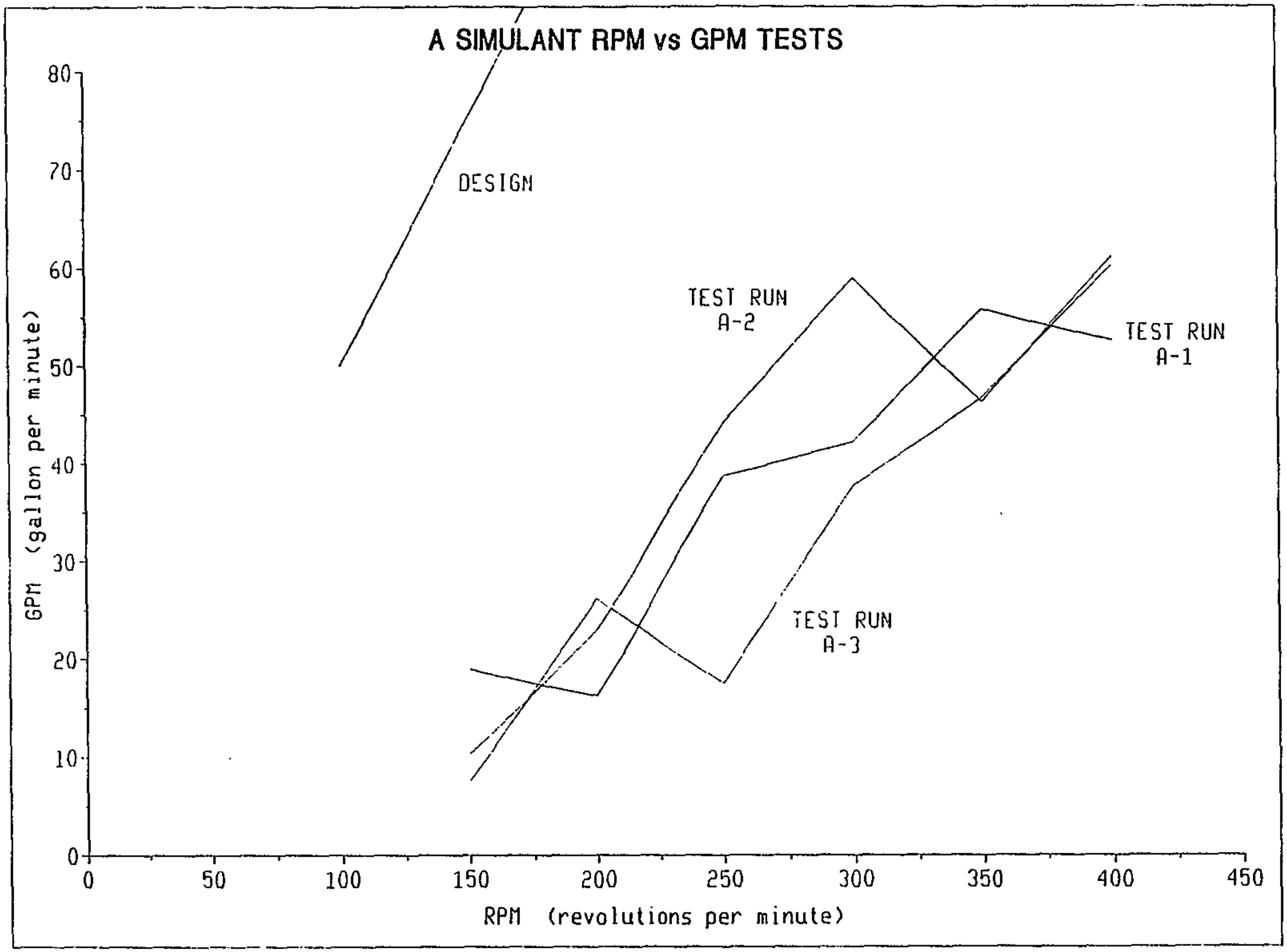


Figure 3. Simulant A RPM Versus GPM Tests.

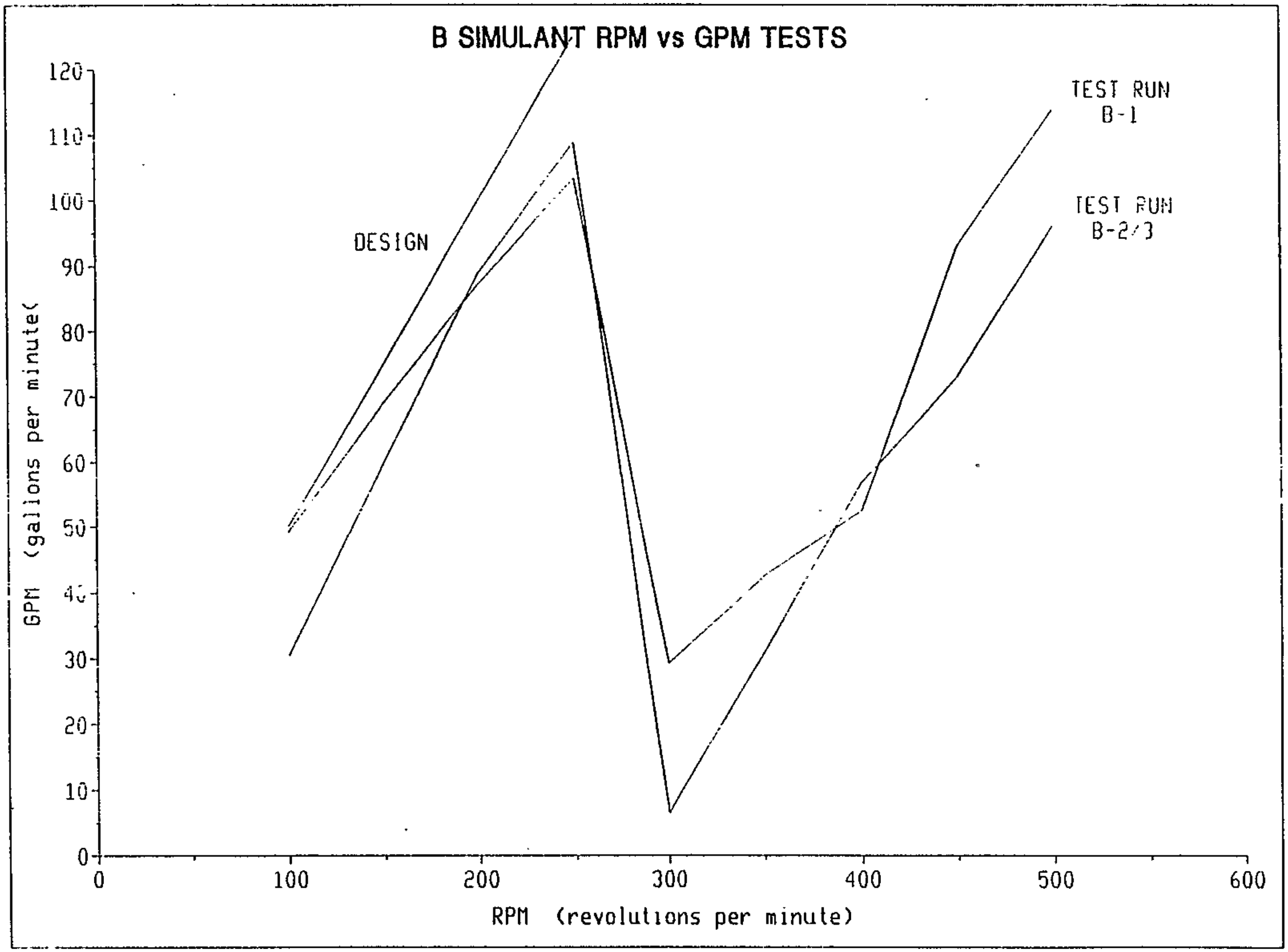


Figure 4. Simulant B RPM Versus GPM Tests.

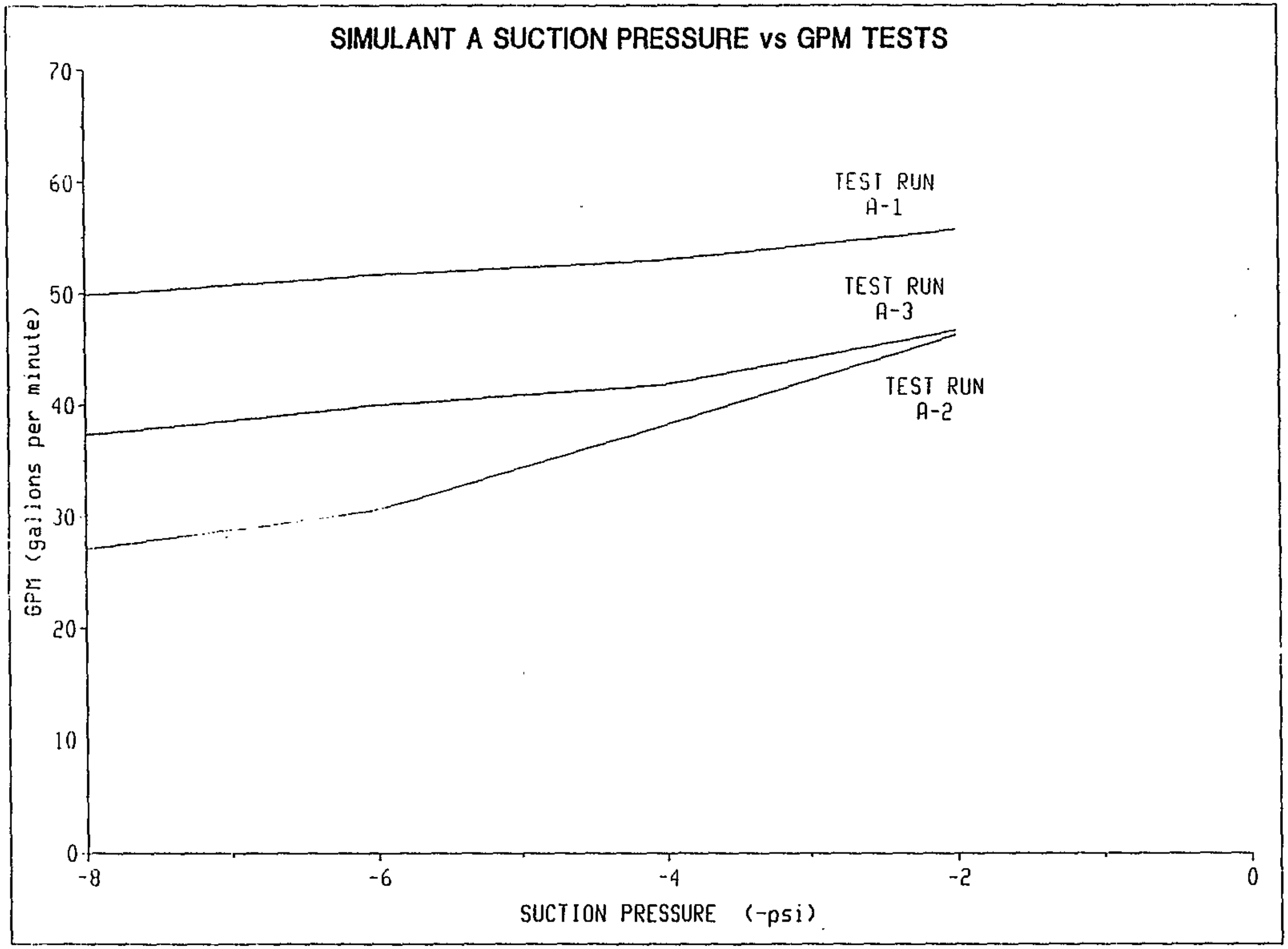


Figure 5. Simulant A Suction Pressure Versus GPM Tests.

9 1 1 2 0 5 2 0 1 1 1

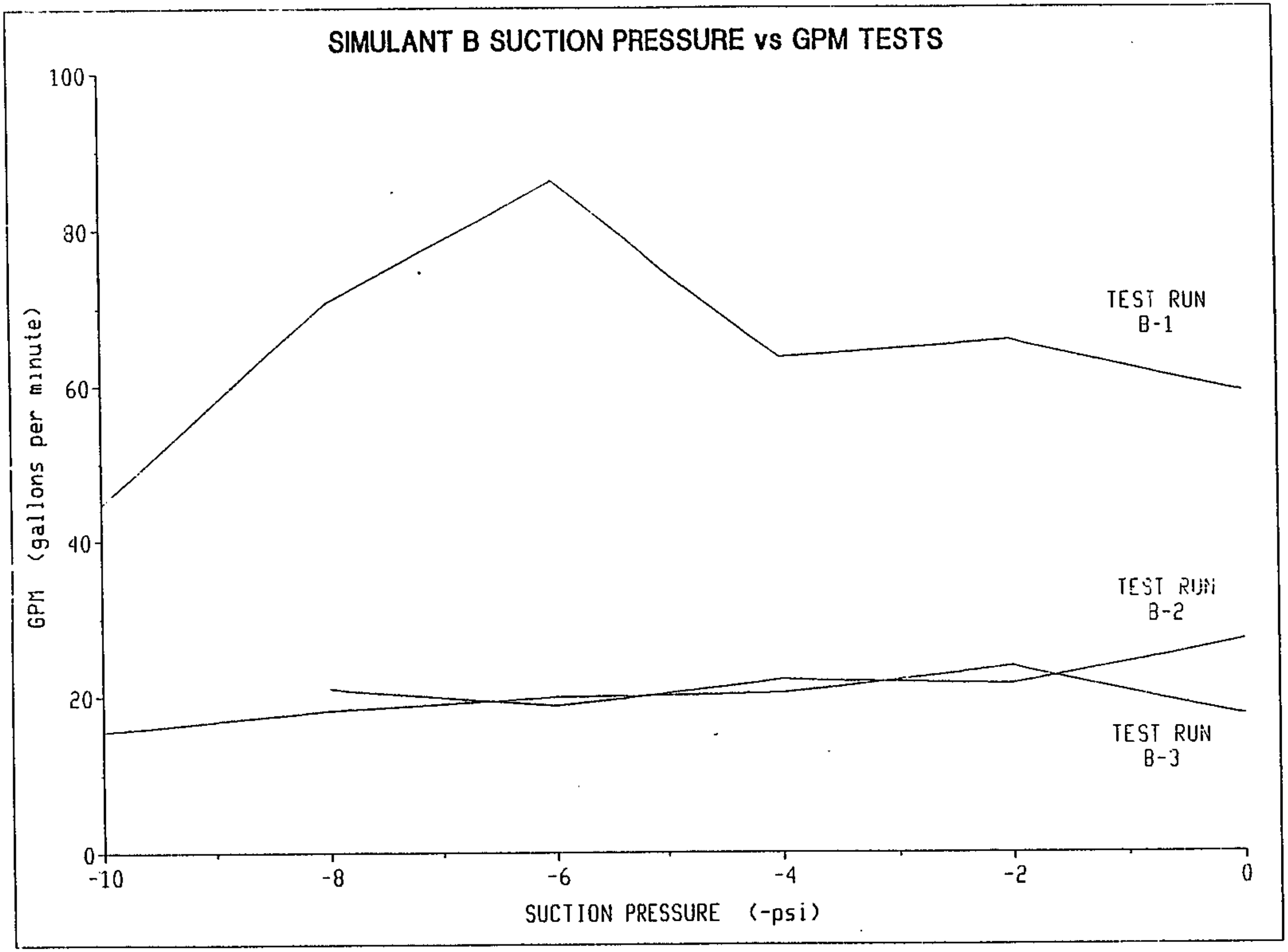


Figure 6. Simulant B Suction Pressure Versus GPM Tests.

6.0 DISPOSITION OF TEST ITEM

The test loop, pump, motor and instruments belong to Beckwith and Kuffel.

7.0 REFERENCES

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Krieg, S. A., W. W. Jenkins, K. J. Leist, K. G. Squires, J. F. Thompson, 1990, *Single-Shell Tank Waste Retrieval Study*, WHC-EP-0352, Westinghouse Hanford Company, Richland, Washington.

Thompson, J. F., 1990, *Single-Shell Tank Retrieval Feature Testing Test Plan*, WHC-SD-ER-TP-002, Westinghouse Hanford Company, Richland, Washington.

A P P E N D I X

VENDOR INFORMATION

Beckwith & Kuffel

WESTINGHOUSE HANFORD COMPANY

SINE PUMP, MODEL SPS-50, TEST REPORT

By: ROBERT M. FOWLER
Beckwith & Kuffel Project Supervisor

September 7, 1990

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FAX 206 767 6230

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TABLE OF CONTENTS

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OPINION

In view of the fact that the SINE Pump was never designed for use in any application other than those found within the food industry, with no known food products having the specific properties of the test simulant, it is my opinion that the software held up very well during the testing process. With a change of fabric the software life could be greatly extended.

Aside from wear, the major problem encountered was that of feeding. After several fillings of the hopper with type A simulant sludge residue builds up on the interior wall of the hopper impeding flow of the product into the pump.

If time spent on the coupling alignment, electrical problems and suction feed problems is discounted it is believed that the test could have been performed over the course of three 8-hour days.

If we were to run the test again we would replace the suction butterfly valve with a knife-type valve; develop a better method for moving the test product from barrel to hopper and relocate the test stand so as to facilitate internal inspection and cleaning of the pump.

Finally, it is my opinion that this type of testing should be run on a "cost plus" basis as there are so many unknown variables affecting the man hours necessary to complete the testing. We discovered that material costing was in line with industry standards, but our labor costs exceeded our budget by 55%.

I would like to state that I enjoyed this project and look forward to working with you in the future.

Respectfully submitted,

Robert M. Fowler

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Beckwith & Kuffel

September 7, 1990

Mr. J.H. Bourgeault
Westinghouse Hanford Company
P.O. Box 1970, G1-59
Richland, WA 99352

RE: **SINE Pump Test Project/Purchase Order MBH-SVV-072554/Job No. 20-0431**

Dear Mr. Bourgeault:

The following report comprises statistical data and obversations taken during the test at Beckwith & Kuffel (B&K), 5930 1st Avenue South, Seattle, Washington 98108, of the SINE Pump, Model SPS-50, pumping two (2) types of sludge (waste simulant) developed and provided by Westinghouse Hanford Company (WHC); the properties of which are shown in Attachment "A" hereto. Specifications for the SINE Pump, Model SPS-50 are shown in Attachment "B" hereto.

The testing of the SPS-50 SINE Pump for WHC under WHC's Purchase Order MBH-SVV-072554, inclusive of Modification No. 1 thereto (a copy of which is attached hereto as Attachment "C") commenced Monday, August 27, 1990 at approximately 10 o'clock a.m..

Those in attendance for this test were:

Ken Squires, Project Engineer, WHC
Dave Ruff, Project Engineering Intern, WHC (present through 8/30/90)
Dale Wamner, Chemical Engineer, WHC (present commencing 8/28/90)
Bob Fowler, Project Supervisor, B&K
Susan Fowler, Recording Secretary for B&K
Dave Kann, Shop Personnel, B&K
Dwayne Dixon, Shop Personnel, B&K

It should be **NOTED** that for this test a 37 horsepower motor was substituted for the 15 horsepower motor specified in WHC's Modified Purchase Order when the need for same was determined during extensive consultations between engineers for SINE Pump and B&K.

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206 • 767 • 6700
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Mr. J.H. Bourgeault
September 7, 1990

Page Two (SINE Pump Test Project Report)

Value data contained in this report were obtained as follows:

Temperature readings via a Taylor Digital Thermocouple Thermometer (probe type);

Weights via a Fairbanks-Morse 2000# Scale, certified and tagged by Fairbanks-Morse on 8/15/90;

Motor and pump speed (RPM) via a Biddle Digital Tachometer;

Amperage (AMP) via a Tong Test Ammeter;

Voltage (V) via built-in volt meter on shunt field power supply;

Brake horsepower (BHP) via calculation utilizing the formula $\frac{AMP \times V}{.746} = BHP$;

Flow rate (GPM) via calculation utilizing the following formulae:

> <u>See</u> Attachment "D" hereto provided by Dave Ruff, WHC engineering intern;

Pressure readings (PSI) via visual inspection of in-line pressure gauges fabricated into test loop design;

Micrometer readings (MIC) were consistently taken by Dave Kann, B&K shop personnel, utilizing N-S-K micrometer instruments and consistently recorded by Susan Fowler, recording secretary for this project;

Diversion time was consistently measured by Bob Fowler, B&K project supervisor, via visual inspection of quartz movement timepiece with second hand.

Water was successfully pumped through the test loop insuring the proper function of the constituents of the loop. Vibration on the motor occurred at 170 PSI, 1040 RPM.

Mr. J.H. Bourgeault
September 7, 1990

Page Three (SINE Pump Test Project Report)

Value data obtained during the three test runs of the two-phase (suction and RPM) testing procedure for both A and B type simulants are recorded on Exhibits A-1, A-2, A-3, B-1, B-2 and B-3 attached hereto and will be more fully discussed as this test report progresses.

It was decided that the sequence of testing should be type B simulant (the lighter weight, less viscous simulant) followed by type A simulant; the purpose therefor being to establish "red line" criteria for the SINE Pump in the event of complete pump failure using the heavier, more viscous type A simulant.

The SINE Pump was disassembled by Dwayne Dixon, B&K shop personnel, and initial pump software measurements (MIC's) were taken as specified by WHC in Section 6.3 (Inspection) of the Test Procedure Document (a copy of which is attached hereto as Attachment "E") and recorded. These initial MIC's are shown on Exhibit 4 attached hereto. The pump was then reassembled and type B simulant was loaded into the hopper.

A sample of this type B simulant was taken, isolated and labeled by Ken Squires, WHC project engineer, and a simulant temperature reading of 70° F. was recorded.

The pump was then started and attempts were made to bring the RPM's to 600 at 125 PSI with the diverter valve closed, all in accordance with Section 5.2 (Procedure) of the Test Procedure Document (<u>see</u> Attachment "E"). While the simulant was successfully pumped through the test loop, severe motor vibration and deafening noise occurred at 580 RPM's.

It was theorized that a problem existed within the front motor bearing (next to the motor/pump coupling) and the system was shut down for inspection. This inspection showed a .012" misalignment in the motor/pump coupling (presumably caused by the severe motor vibration) and an electrician was brought in to troubleshoot the electrical end of the system. The electrician discovered a failure in the full wave rectifier bridge for the shunt field power supply. This part was replaced, the motor/pump coupling alignment was corrected and the system reassembled. The system was then test run (without data recordation) to determine that the electrical and alignment problems had been corrected.

At this time it was decided by Ken Squires, WHC project engineer, and Bob Fowler, B&K project supervisor, that due to the late afternoon hour the testing of the simulant should be shut down for the day and resumed the following morning.

Mr. J.H. Bourgeault
September 7, 1990

Page Four (SINE Pump Test Project Report)

The testing on type B simulant recommenced Tuesday morning, August 28, 1990, with the suction phase of the test. Statistical data obtained is shown on Exhibit B-1-1. It should be **NOTED** that during the -6 PSI test run the amount of simulant in the test loop was exhausted after approximately 5 seconds of diversion time so no valuable data was obtained for this run. It should be further **NOTED** that at -10 PSI serious cavitation occurred.

The testing proceeded with the RPM phase of the test. Statistical data obtained is shown on Exhibit B-1-2. A shut off test was performed at the request of Ken Squires, WHC project engineer, and a reading of 49 PSI was achieved. It should be **NOTED** that testing above 500 RPM's could not be performed due to BHP limitation.

After the completion of this first test run on type B simulant the pump was disassembled for inspection and measurement. MIC's obtained are shown on Exhibit 5 attached hereto. It should be **NOTED** that slight scoring and pitting was observed on the suction and discharge surfaces of the scrapergate. It should be further **NOTED** that even though a loss of .020" in the wall of the scrapergate support was recorded the scrapergate support was not rotated.

The pump was reassembled with all of the original software and testing was suspended for the day due to the late afternoon hour.

The second test run on type B simulant commenced on Wednesday morning, August 29, 1990, beginning with the suction phase of the test. Statistical data obtained is shown on Exhibit B-2-1. It should be **NOTED** that serious cavitation occurred once again at -10 PSI and pressure on the discharge side fell to Ø PSI.

The second run on type B simulant proceeded with the RPM phase of the test. Statistical data obtained is shown on Exhibit B-2-2. It should be **NOTED** that at 357 RPM's with 125 PSI there was very little flow of simulant into the catch tank and the pump became increasingly noisier. It was decided to stop the test and disassemble the pump for inspection and measurement. MIC's obtained are shown on Exhibit 6 attached hereto. It should be **NOTED** that medium to heavy scoring and pitting was now observed on the suction and discharge surfaces of the scrapergate. It should be further **NOTED** that slight scoring was observed around the outside wall of the shaft sleeve at the points of contact with the 3 lip seals. Too, it should be **NOTED** that scoring was observed on the 4 points of the pump impeller though no MIC's were taken on the impeller at this time.

Mr. J.H. Bourgeault
September 7, 1990

Page Five (SINE Pump Test Project Report)

Due to the lengthy "down time" during this inspection and measurement phase it was decided to suspend testing for the rest of the day and recommence testing the following morning after replacement of the scrapergate, rotation of the scrapergate support and replacement of the "O" ring on the shaft sleeve that was damaged during the disassembly process. MIC's on the replacement scrapergate and rotated scrapergate support are shown on Exhibit 7.

The third test run on type B simulant commenced Thursday morning, August 30, 1990, with the suction phase of the test. Statistical data obtained is shown on Exhibit B-3-1. It should be **NOTED** that due to the reduced flow rates obtained during this third test run of the suction phase testing on type B simulant Bob Fowler, B&k project supervisor conferred with the engineering department of SINE Pump and was informed that there were 3 possible problem areas which would result in reduced flow rates: 1) the scrapergate could be worn out; 2) there could be excessive wear on the impeller; and 3) the shaft sleeve be scored due to abrasion causing the pump to suck air. Since scoring on the outside wall of the shaft sleeve had been observed during the previous disassembly and inspection it was decided to once again disassemble the pump and replace the shaft sleeve. The scrapergate was also replaced. Too, it was decided during this disassembly to measure the extent of wear on the 4 points of the pump impeller. MIC's obtained on the replacement shaft sleeve, the pump impeller and the replacement scrapergate are shown on Exhibit 8 attached hereto. It was also decided during this assembly that the thinning of the simulant throughout the testing process could be a causative factor in the reduced flow rates. Consequently, a complete set of MIC's on the software was recorded prior to filling the hopper with the last original barrel of type B simulant--simulant of the same consistency used during the first test run on type B simulant when highest flow rates were obtained. These MIC readings are shown on Exhibit 9 attached hereto. A sample of the "thinned" type B simulant was taken, isolated and labeled by Ken Squires, WHC project engineer.

With the pump now reassembled and the hopper filled with the last original barrel of type B simulant the RPM phase of the third test run on type B simulant commenced. Statistical data obtained is shown on Exhibit B-3-2. During this phase of the testing another shut off test was requested by Ken Squires, WHC project engineer, and a reading of 92 PSI was achieved.

At the completion of the 3 test runs on type B simulant the pump was once again disassembled for inspection and measurement. MIC's obtained are shown on Exhibit 10 attached hereto. A final sample of type B simulant was taken, isolated and labeled by Ken Squires, WHC project engineer.

Mr. J.H. Bourgeault
September 7, 1990

Page Six (SINE Pump Test Project Report)

It should be **NOTED** that visual observations during this inspection showed that the shifting of the pump liners caused light to medium scoring of the pump casing during the testing process on type B simulant. The pump was then reassembled.

At this time the test loop was cleaned of all type B simulant preparatory to testing of the type A simulant.

Type A simulant was then laboriously loaded into the hopper by means of a clean shovel--the properties of this type A simulant rendering the simulant non-pourable. It should be **NOTED** that at this first loading of the type A simulant into the hopper the interior wall of the hopper was devoid of any simulant residue and the suction valve was wide open. These conditions combined with the bulk weight of the simulant and the force of gravity permitted downward flow of the simulant into the pump thus creating a self-prime on the pump.

It was decided that a pre-test should be run through the test loop simply to determine whether the pump was capable of pumping this type A simulant. At 102 RPM's 40 PSI was achieved with the discharge valve completely closed. The discharge valve was then opened, the RPM's were increased to 106, 40 PSI was achieved and an intermittent "plopping" discharge into the catch tank was observed. Thr RPM's were increased to 150 and 40 PSI was achieved with the discharge valve 90% closed. PSI increased to 60 when the valve was completely closed. At 200 RPM's 70 PSI was achieved with the valve closed.

At this time it was determined that the pump was capable of pumping the type A simulant and the RPM phase of the first test run on type A simulant commenced for recordation purposes. Statistical data obtained is shown on Exhibit A-1-2. Due to the late afternoon hour testing for the day was shut down after the test run at 350 RPM's at 48 PSI with -2.5 suction produced a more constant discharge flow. The remaining simulant within the test loop was then pumped out of the system at the suggestion of Dale Wamner, WHC chemical engineer.

The first RPM test run on type A simulant recommenced on Friday morning, August 31, 1990, with the type A simulant again being loaded into the hopper. It should be **NOTED** that at this loading of the simulant there was simulant residue from the previous test run clinging to the hopper wall (as no water had been run through the system the previous evening so as to preclude contamination of the simulant which would be needed to complete the testing) and the suction valve was closed combining to create a bridge at the suction valve causing feed problems of the simulant into the pump. The simulant had to be hand packed into the pump in order to effect prime on the pump.

Mr. J.H. Bourgeault
September 7, 1990

Page Seven (SINE Pump Test Project Report

Once the pump was so primed the RPM phase of the first test run on type A simulant continued with statistical data obtained also shown on Exhibit A-1-2. It should be NOTED that no testing was done above 400 RPM's as vibration and heavy hammering was observed at this speed.

At the completion of the first test run of the RPM phase on type A simulant the pump was disassembled for inspection and measurement of the scrapergate. MIC readings obtained are shown on Exhibit 11 attached hereto. The scrapergate was replaced and MIC readings obtained on the replacement scrapergate are shown on Exhibit 12 attached hereto.

The second and third test runs of the RPM phase on type A simulant were then completed without incident excepting as NOTED previously relative to feed and prime problems. Statistical data obtained is shown on Exhibits A-2-2 and A-3-2, resepctively.

The suction phase of all 3 test runs on type A simulant then commenced. Statistical data obtained is shown on Exhibits A-1-1, A-2-1 and A-3-1, respectively. It should be NOTED that no test runs were made at this time with the suction set at -2 as the RPM phase of the test on type A simulant had been run with suction set at -2.5. It should be further NOTED that no test runs were made with the suction set at -10 as heavy hammering occurred on the test runs with the suction set at -8.

At the completion of the testing of type A simulant a sample of type A simulant was taken, isolated and labeled by Ken Squires, WHC project engineer. The pump was then disassembled for inspection and measurement. This final set of MIC readings is shown on Exhibit 13 hereto.

Respectfully submitted,

BECKWITH & KUFFEL

By Robert M. Fowler
Robert M. Fowler
Beckwith & Kuffel Project Supervisor

RMF/srf

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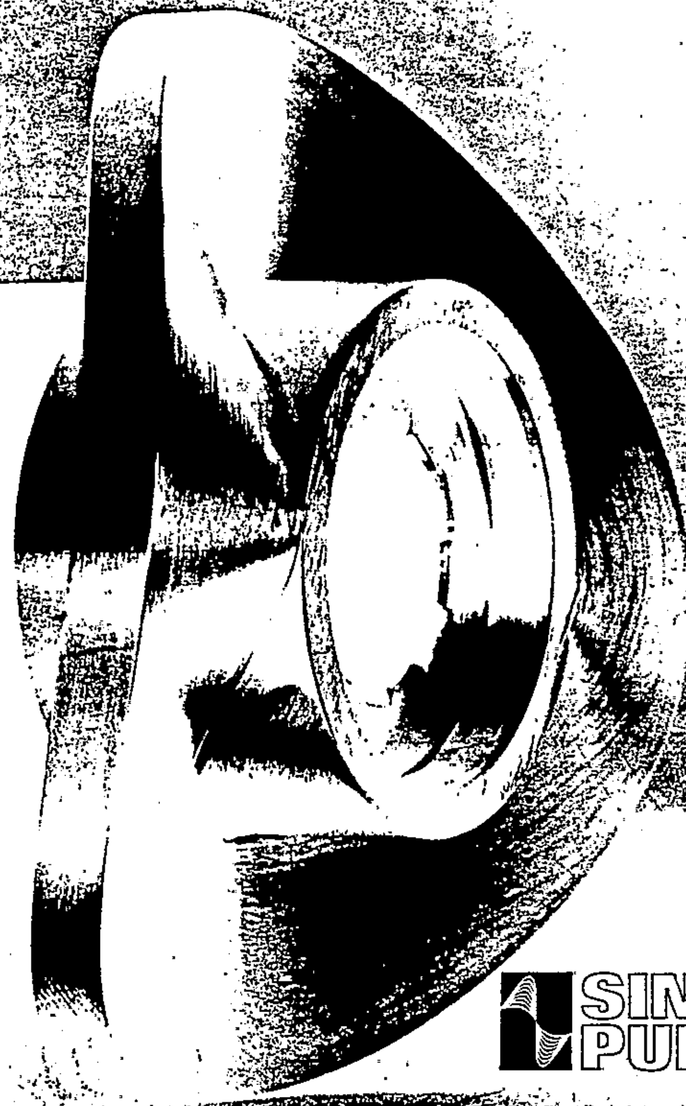
<u>Simulants</u>	Density (g/ml) (+/-15%)	/ Flow Rates \ Volumetric (GPM)	Mass (lbm/min) (+/-15%)	Viscosity (cp) (+/-15%)	Volume (gal)
Type-A	1.6	30	400	1,700,000	120
Type-B	1.3	60	650	40	240

Attachment "A"

Bulletin SPS/891

The gentle wave



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ROBERT (BOB) FOWLER

SINE PUMP®

SINE PUMP®

GENTLE, YES. BUT POWERFUL & EFFICIENT, TOO.

The **Sine Pump** is the only positive displacement pump utilizing the space-age technology of the three-dimensional sinusoidal curve. It combines the most advantageous benefits of both rotary lobe and progressing cavity pumps, while eliminating the disadvantages of both earlier designs. No other pump can match the **Sine Pump**'s ability to handle viscous, shear-sensitive or aggregate liquids while providing powerful suction lift and a pulse-free laminar flow.

LOWEST SHEAR: The single-rotor, single-shaft design combines to create a compression-free transfer of liquid through the pumping cycle, enabling the **Sine Pump** to handle shear sensitive products with the gentleness of the human hand. This GENTLE WAVE motion has resulted in unexpected benefits to processors, such as higher butterfat yields in dairy processing; and elimination of unwanted air bubbles in shampoos and gel products.

HIGH VISCOSITY: The **Sine Pump** is frequently used in applications with liquids having viscosities over 1,000,000 cps. The constant volumetric displacement means that viscosity is barely felt in the pump itself and the laminar flow often results in reduced line pressure; hence, reduced horsepower required.

AGGREGATE LIQUIDS: The Sine Pump handles large, fragile particulates far better than other pumps with equivalent displacement. This means you do not have to use a hydraulically oversized pump to maintain the integrity of your product.

POWERFUL SUCTION: The **Sine Pump** will pull a vacuum lift of 30 feet (9 meters) of water, and often eliminates the need for auxilliary feeders even when handling highly viscous liquids.

PULSE-FREE FLOW: Zero pulsation in the **Sine Pump** means less damage to your product, longer life for the pump and adjacent equipment, elimination of pressure "spikes" in the process line, and a smooth, meterable flow of your product.

BEATS OTHER *sanitary* positive displacement pumps: The **Sine Pump** makes older rotary lobe and progressing cavity pump designs obsolete. It eliminates the high shearing and pulsation of lobe and circumferential piston pumps, and doesn't lose performance with increased viscosity as lobe pumps do. The Sine Pump consumes far less horsepower, application for application, than progressing cavity pumps do; does not require frequent and expensive stator replacement; and the **Sine Pump**'s far smaller "footprint" makes it fit much more conveniently into most processing lines. The **Sine Pump**'s Hardware/Software System design concept makes it far easier and less expensive to maintain than any other sanitary positive displacement pump.

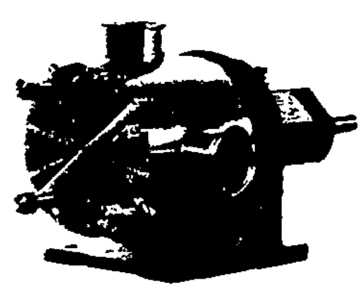
THE HARDWARE/SOFTWARE SYSTEM: The **Sine Pump**'s unique Hardware/Software System insures (1) each pump employs the best materials of construction for your application; (2) you enjoy fast and easy maintenance with inexpensive, easy-to-replace parts; (3) you can easily modify your **Sine Pump** for a wide variety of different applications within your plant; and (4) you have complete protection of the more costly "hardware" components — no more expensive rebuilds resulting in mismatched pumps; no more need to carry complete spare pumps for emergencies.

APPROVALS: The **Sine Pump** holds every major sanitary processing approval: USDA for both meat and poultry and for dairy, and 3A for dairy applications. All materials within the **Sine Pump** are FDA suitable for sanitary processing.

LABORATORY: The **Sine Pump** Company maintains a complete sanitary laboratory facility and staff for pump and applications testing.

PRODUCTION AND QUALITY ASSURANCE: The **Sine Pump** is manufactured using the most modern CNC machining centers, and is backed up by a 100% Quality Assurance program.

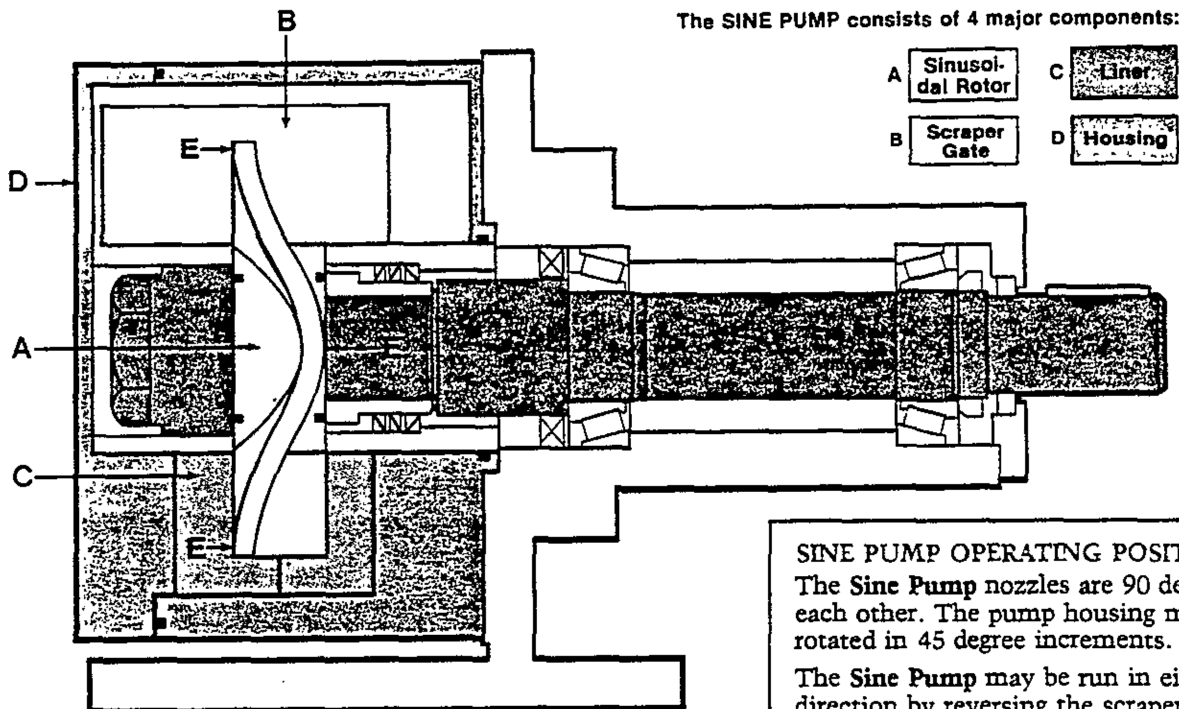
SALES AND SERVICE NETWORK: **Sine Pump** customers are assured of the immediate attention and local expertise of a nationwide network of factory-trained representatives and stocking distributors.



PRINCIPLES OF OPERATION

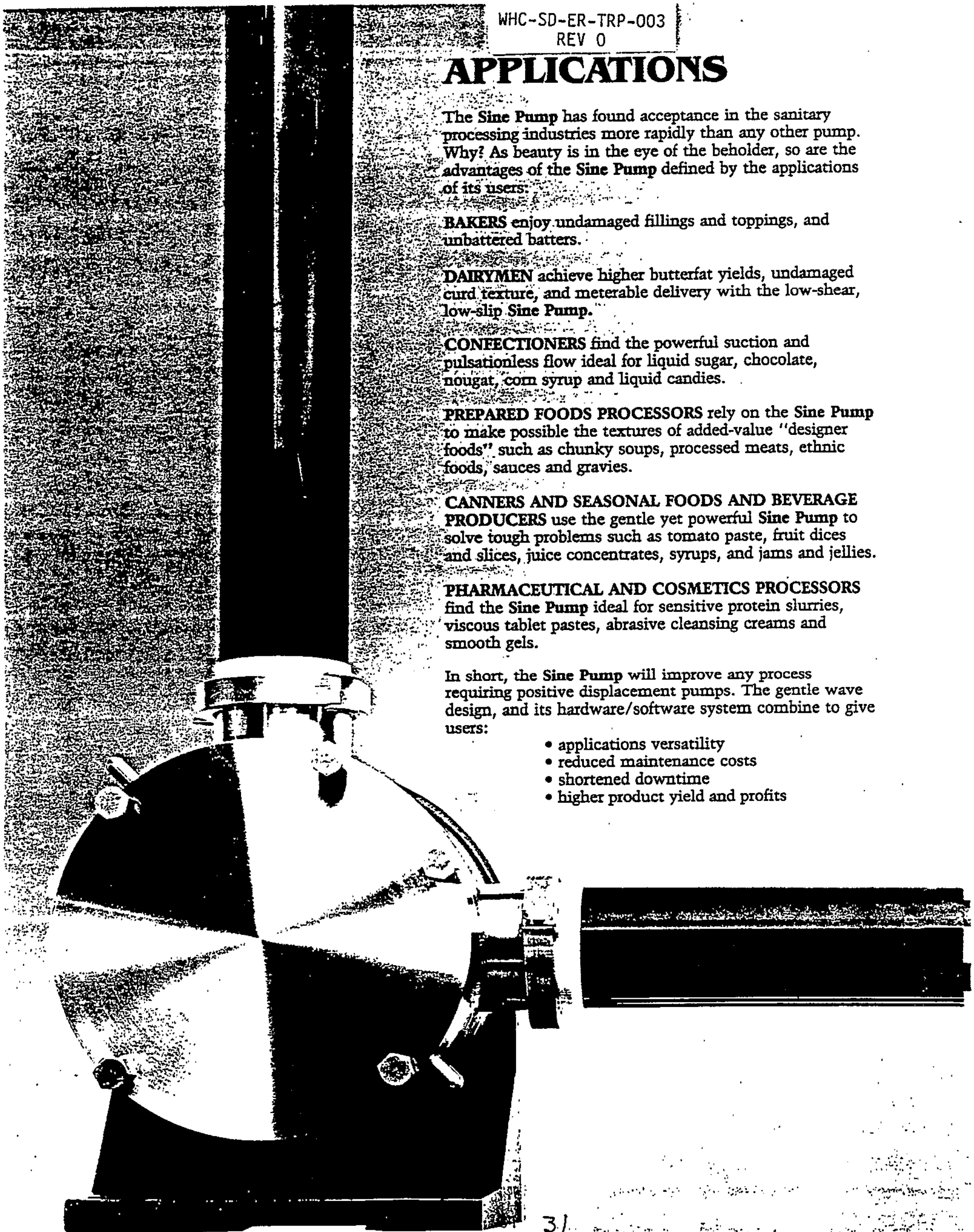
MECHANICALLY UNIQUE: The cross-sectional diagram below illustrates how the patented **Sine Pump** can move liquids without shear, slip or pulsation: Rotor "A" is a sinusoidal "impeller" in which two complete sine curves create four separate, symmetrical pumping compartments. As the rotor turns in the housing (D), these compartments travel through liners (C), providing a positive displacement of liquid from suction to discharge. The sliding scraper gate (B) prevents return of product past the discharge and back to the suction side of the pump. The high points of the sine curve (E) are always in contact or close proximity to the liners and scraper gate, assuring low slip operation and a powerful suction lift. The **Sine Pump**'s four large pumping compartments never change in volume, eliminating compression within the pump or any damage to particulate. Since the suction port's volumetric area is always the same and both sides of the sine curve rotor are fed simultaneously, there is no pulsation, no axial thrusting, and negligible effect from viscosity within the pump.

HARDWARE/SOFTWARE SYSTEM: The scraper gate, liners, seals and O-rings are considered "software" items, meaning that they are available in a variety of materials or configurations best suited to your application. They are easily replaced without removing the pump from the line, for maintenance or for change of application. "Hardware" items are those parts which are always the same, such as the rotor, shaft, housing and cover, and bearing housing assembly. Unlike conventional rotary pumps which become expensive "throw-aways" as they wear, the **Sine Pump**'s wear parts are its least expensive components, and it can always be returned to first class condition at reasonable cost.



SINE PUMP OPERATING POSITIONS:
The **Sine Pump** nozzles are 90 degrees to each other. The pump housing may be rotated in 45 degree increments.

The **Sine Pump** may be run in either direction by reversing the scraper gate and guide.



APPLICATIONS

The **Sine Pump** has found acceptance in the sanitary processing industries more rapidly than any other pump. Why? As beauty is in the eye of the beholder, so are the advantages of the **Sine Pump** defined by the applications of its users:

BAKERS enjoy undamaged fillings and toppings, and unbattered batters.

DAIRYMEN achieve higher butterfat yields, undamaged curd texture, and meterable delivery with the low-shear, low-slip **Sine Pump.**

CONFECTIONERS find the powerful suction and pulsationless flow ideal for liquid sugar, chocolate, nougat, corn syrup and liquid candies.

PREPARED FOODS PROCESSORS rely on the **Sine Pump** to make possible the textures of added-value "designer foods" such as chunky soups, processed meats, ethnic foods, sauces and gravies.

CANNERS AND SEASONAL FOODS AND BEVERAGE PRODUCERS use the gentle yet powerful **Sine Pump** to solve tough problems such as tomato paste, fruit dices and slices, juice concentrates, syrups, and jams and jellies.

PHARMACEUTICAL AND COSMETICS PROCESSORS find the **Sine Pump** ideal for sensitive protein slurries, viscous tablet pastes, abrasive cleansing creams and smooth gels.

In short, the **Sine Pump** will improve any process requiring positive displacement pumps. The gentle wave design, and its hardware/software system combine to give users:

- applications versatility
- reduced maintenance costs
- shortened downtime
- higher product yield and profits

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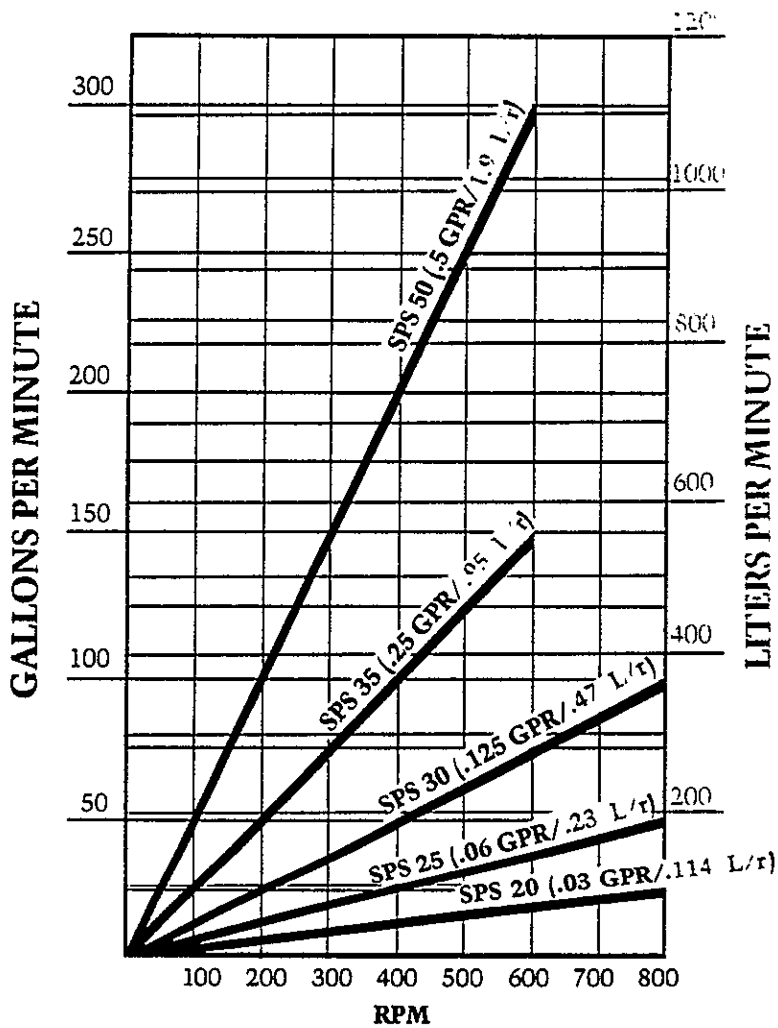
PERFORMANCE



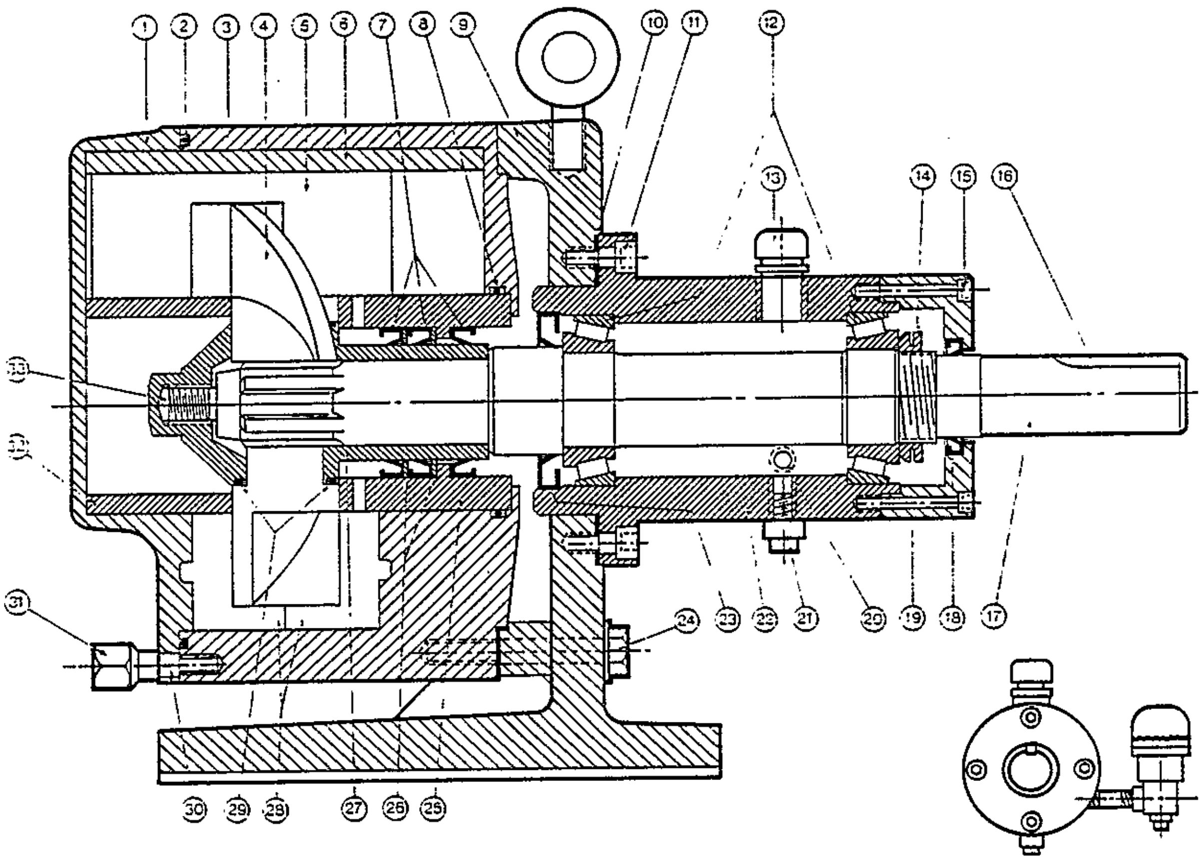
The five **Sine Pump** models are designed to complement each other to provide a family of capabilities without gaps where costly oversizing would be necessary. Each succeedingly larger pump is designed to pick up in capacity where the next smaller one left off.

THE SINE PUMP:

- Flows to 450 GPM.
- Pressures to 150 psig.
- Few, simple parts.
- Cleans in place.
- High power efficiency.
- Temperatures to 300°.
- Excellent abrasive-handling capability.
- Negligible slip.
- Easy maintenance.
- Self-compensating for wear.
- Powerful suction.

SINE PUMP®

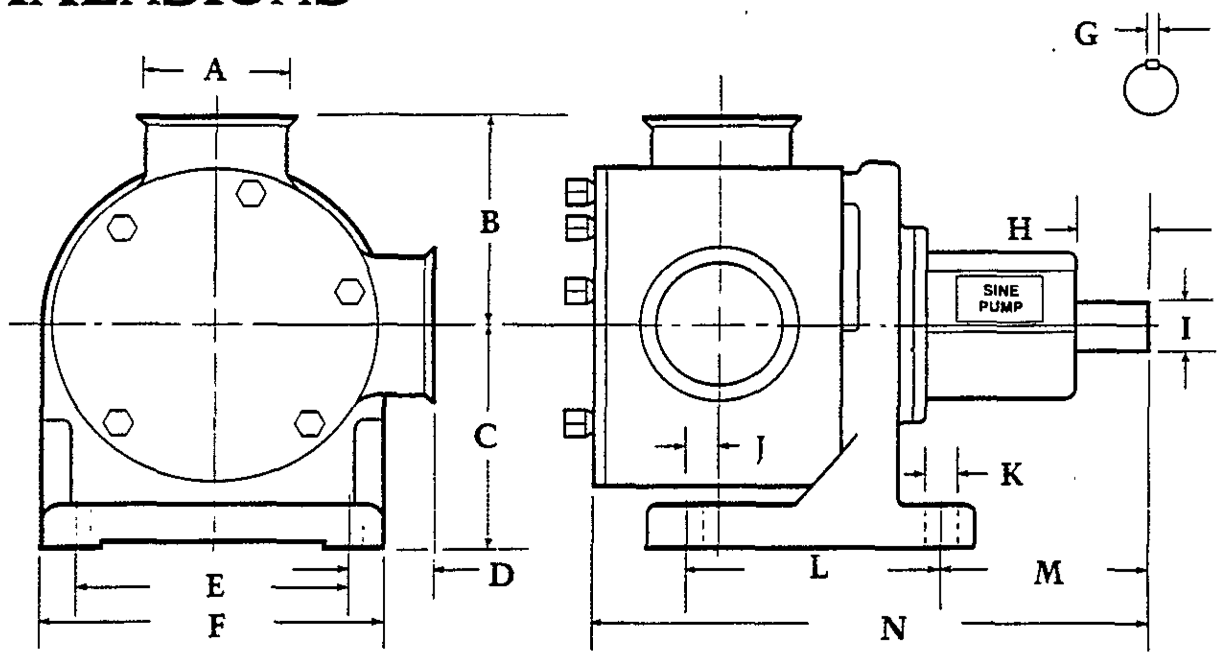
CROSS SECTION AND PARTS



Detail, Part 20

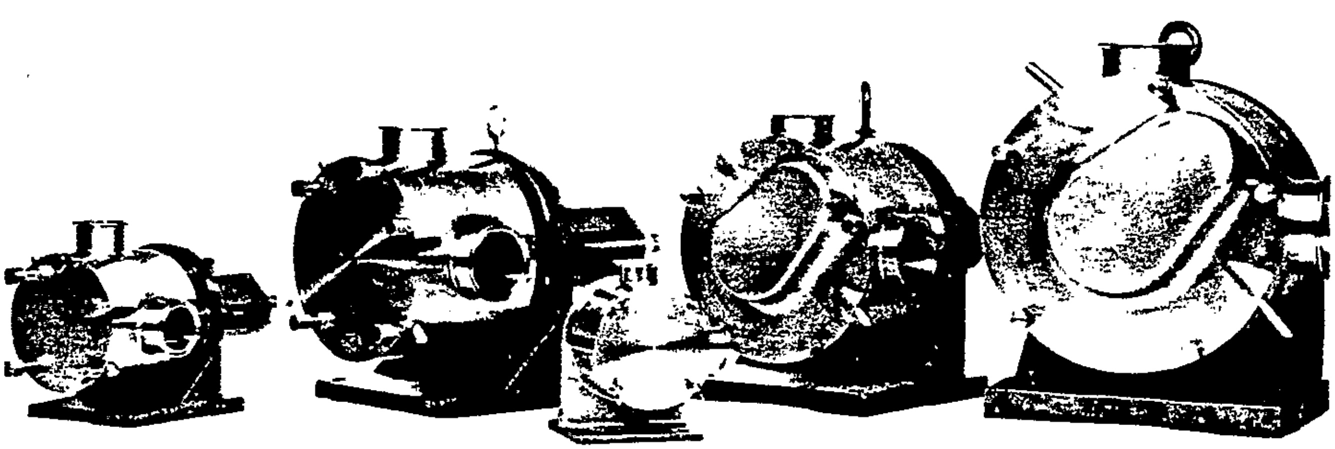
No.	Part	No.	Part	No.	Part
1	Front Cover	12	Tapered Roller Bearings	23	Inboard Oil Seal
2	Front Cover O-Ring	13	Oil Vent	24	Housing Mounting Bolt
3	Pump Housing	14	Lock Nut	25	Seal Housing
4	Rotor	15	Bearing Housing Cap Screw	26	Lipseal Support Ring
5	Scraper Gate	16	Shaft Key	27	Shaft Sleeve
6	Scraper Gate Guide	17	Shaft	28	Liners
7	Lip Seals	18	Outboard Oil Seals	29	Rotor O-Rings
8	Seal Housing O-Ring	19	Bearing Housing Cap	30	Front Cover Mounting Stud
9	Power Frame	20	Oil Reservoir	31	Front Cover Nut
10	Shim	21	Drain Plug	32	Scraper Gate Support
11	Power Frame Cap Screw	22	Bearing Housing	33	Shaft Nut

DIMENSIONS



Model No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
20	2	4 5/8	4 5/16	2 3/16	4 1/2	6 1/2	5/16	2 3/4	25	1	1/2	6	6 11/16	14 3/8	Inches
	50	117	110	56	114	165	8	70		25.4	13	152	170	365	mm's
25	2.5	5 1/4	5 3/4	2 1/4	6	7 1/2	5/16	2.9	25	.84	1/2	6 1/2	6 3/4	15 1/4	Inches
	65	133	146	57	152	190	8	74		21	13	165	171	387	mm's
30	3	6 1/4	7	2 1/8	8 1/4	10 1/4	13/32	2 11/16	38	1 1/2	11/16	7 11/16	8 7/8	8 11/16	Inches
	75	159	178	54	210	260	10	68		38	17	195	225	475	mm's
35	3	6 9/16	7 5/8	2 5/16	8 1/2	10 15/16	13/32	4 1/16	38	1 5/8	11/16	9	9 13/16	19 13/16	Inches
	75	167	194	59	216	278	10	103		41	17	229	249	503	mm's
50	4	8 7/32	9 1/4	2 31/32	10 1/2	13 1/4	5/8	5 3/8	50	1 1/8	13/16	10	11 7/8	23 3/4	Inches
	100	209	235	75	267	337	16	136		29	21	254	302	603	mm's

NOTE: TOLERANCE ON DIMENSIONS = ± 1/16 1.5mm



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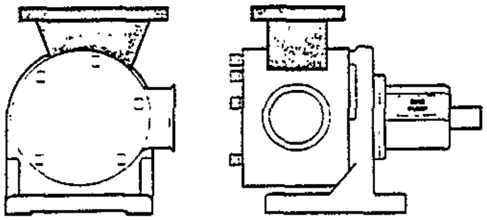
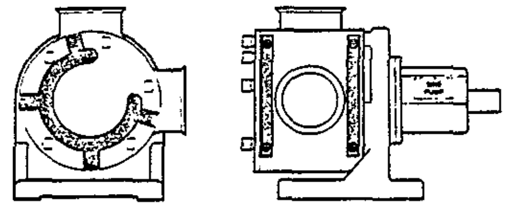
OPTIONS

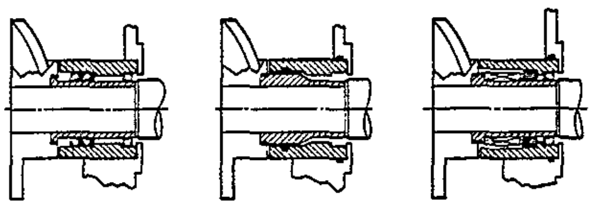


Rectangular suction port option for anti-bridging: The larger sizes of Sine Pumps may be ordered with rectangular suction nozzles which offer expanded suction area for anti-bridging action. A common option for meat emulsions, doughs and other heavy or sticky products, the Sine Pump's rectangular suction ports enhance the power of gravity for smooth, continuous pump feed. Its 90° nozzle configuration means an additional elbow is not needed, so the Sine Pump requires less vertical space than rotary lobe pumps. Mating hoppers are also available.

Superior jacketing for more effective heating/cooling: Rotary lobe pump manufacturers offer cover jackets only. The Sine Pump's unique design allows for separate jackets in the cover and in the pump housing. This second jacket lies approximate to the point where heat transfer is most critical, the seal area. Jacketed Sine Pumps are an ideal solution for maintaining stability in heat-sensitive liquids.



SEAL SYSTEMS



Triple Lip **Single O-Ring** **Inboard Single Mechanical**

NOZZLES

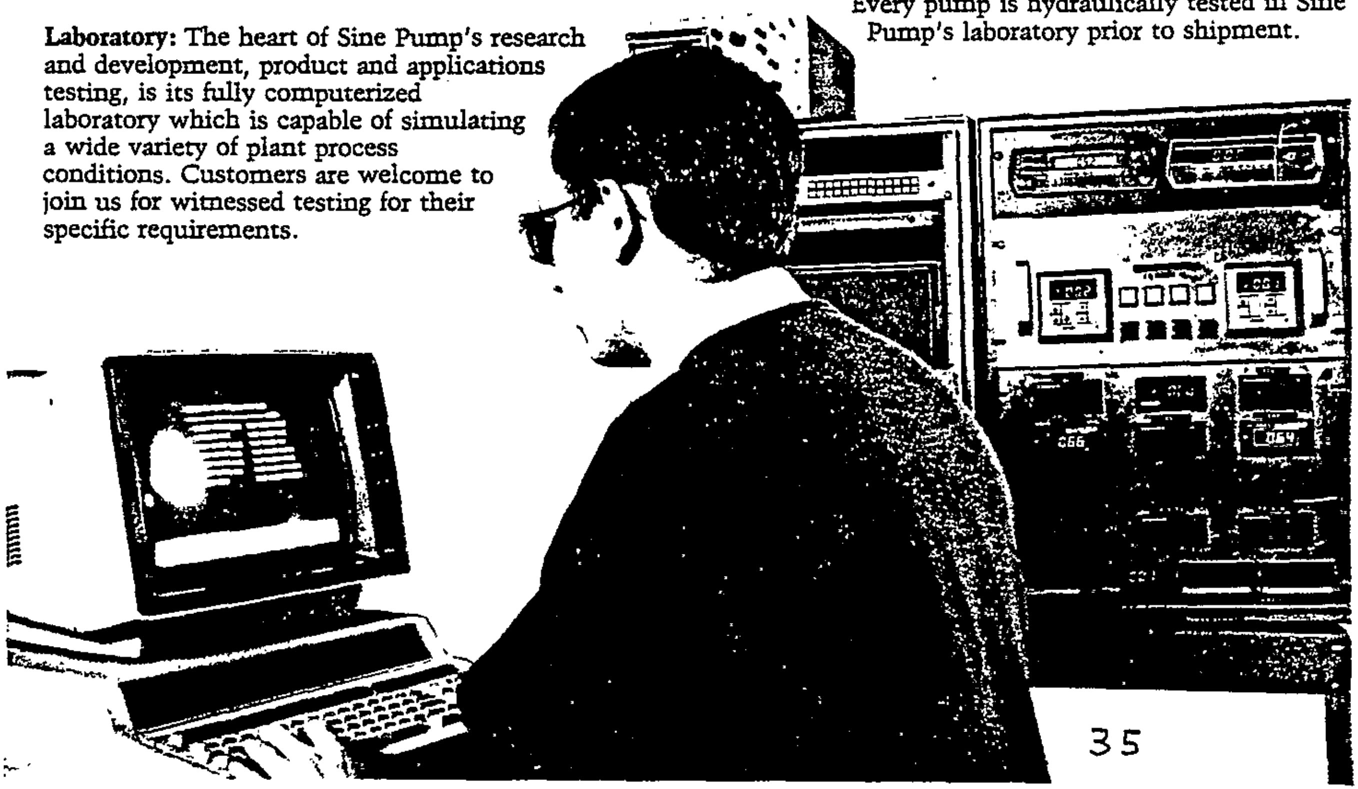
The Sine Pump is furnished with Tri-clamp nozzle fittings as standard. It is also available with a wide variety of optional port configurations including ACME bevel seat, I-line, IDF, John Perry, 150 lb. ANSI flanges, DIN and others as required.

QA

Quality assurance: Using the latest inspection equipment and technology, Sine Pump's 100% quality assurance program insures that every pump meets material, dimensional and performance standards. Every pump is hydraulically tested in Sine Pump's laboratory prior to shipment.

TESTING

Laboratory: The heart of Sine Pump's research and development, product and applications testing, is its fully computerized laboratory which is capable of simulating a wide variety of plant process conditions. Customers are welcome to join us for witnessed testing for their specific requirements.



54-9600-161 (9/89)

PURCHASE ORDER

Westinghouse Hanford Company WHC-SD-ER-TRP-003 REV 0

Westinghouse Hanford Company
A subsidiary of Westinghouse Electric Corporation
P. O. Box 1970 Richland, Wa. 99352

Telephone 509/ 376-6273

U S Government Contract No. DE-AC06-87RL10930

Total Pages (Buyer Insert)

Mo.,Day/Yr.	Page	Inquiry No.	This order is priority rated	Certified Under D P A.S. Reg. (15CFR350)	Vendor Code	Order No.
08 16 90	1	W-072554	DO-E 2		58290	MOD. NO. 1 MBH-SVV-072554

IMPORTANT
Show Order No. on all packages, invoices, and correspondence. Complete packing list must accompany each shipment. Failure to properly identify will delay receipt of shipment and payment.

BECKWITH AND KUFFEL
302 TORBETT STE 224
RICHLAND WA 99352

SHIP TO: 1
1. Westinghouse Hanford Company Central Receiving 2355 Stevens Drive Richland, Washington 99352
2. As indicated below.

O B	Date Delivery Required at F O.B. Point	Buyer
RICHLAND, WA	09-14-90	J H BOURGEAULT G1-59

Terms of Payment	Code Ship Via
ET 30 DAYS	10 PREPAID

ITEM	QUANTITY	U M	DESCRIPTION	UNIT PRICE	TOTAL PRICE
			Confirming Order if Checked ☐		
			THE FOLLOWING ORDER ITEM AND PURCHASE ORDER IS CHANGED AS A RESULT OF THIS MODIFICATION. ITEM NO. 1 IS CHANGED TO READ:		
1	1	LOT	TECHNICAL SERVICES SUPPORT - TESTING OF SINE PUMP IN ACCORDANCE WITH BUYER'S STATEMENT OF WORK ATTACHMENT "A" REVISION DATED 8-8-90 ATTACHED HERETO AND MADE A PART HEREOF.	16775.00	16775.00
			PURCHASE ORDER PROVISIONS ARE REVISED AS FOLLOWS:		
			ITEM 5 OF BUYER'S LIST OF ATTACHMENTS J03 IS REVISED TO READ:		
			5. ATTACHMENT "A" - STATEMENT OF WORK, REVISED 8-8-90.		
			AMOUNT OF ORIGINAL ORDER 16775.00		

Provisions of the terms and conditions specifically included herein by WHC are made a part of this order

Billing Instructions: Render invoices in triplicate to Attention: Accounts Payable
Do not include Washington State Sales Tax or compensating tax in the price of this order (Washington State Registration Number C-600-018-786)
Attach original bill of lading on all collect shipments and support all prepaid freight charges with the original paid freight bill

Westinghouse Hanford Company

J H Bourgeault 8/17/90
Signature Date

Attachment "C"

54-9600-161 (9/89)

PURCHASE ORDER

Westinghouse Hanford Company

WHC-SD-ER-TRP-003
REV 0

Westinghouse Hanford Company
A subsidiary of Westinghouse Electric Corporation
P. O. Box 1970 Richland, Wa. 99352

SAR U4C122 Telephone 509/ 376-6273

U. S. Government Contract No. DE-AC06-87RL10930

Total Pages (Buyer Insert)

Mo. Day Yr	Page	Inquiry No.	This order is priority rated	Certified Under D P A S Reg. (15CFR350)	Vendor Code	Order No.
08 16 90	2	W-072554	DO-E 2		58290	MOD. NO. 1 MBH-SVV-072554

IMPORTANT

Show Order No. on all packages, invoices, and correspondence. Complete packing list must accompany each shipment. Failure to properly identify will delay receipt of shipment and payment

BECKWITH AND KUFFEL

SHIP TO:
1. Westinghouse Hanford Company
Central Receiving
2355 Stevens Drive
Richland, Washington 99352
2. As indicated below.

F O B

Date Delivery Required at F O.B. Point

Buyer

Terms of Payment

Code Ship Via

ITEM	QUANTITY	U M	DESCRIPTION	UNIT PRICE	TOTAL PRICE
			Confirming Order if Checked		
			MOD. NO. 1 NO CHANGE .00		
			NEW TOTAL AMOUNT 16775.00		

Provisions of the terms and conditions specifically included herein by WHC are made a part of this order.

Billing Instructions: Render invoices in triplicate to
Attention: Accounts Payable
Do not include Washington State Sales Tax or compensating tax in the price of this order. (Washington State Registration Number C-600-018-786)
Attach original bill of lading on all collect shipments and support all prepaid freight charges with the original paid freight bill.

Westinghouse Hanford Company

Signature [signature] Date 8/17/

00

PAGE	NUMBER MOD NO. 1
3	MRH-SVV-072554

SELLER ACKNOWLEDGEMENT (R03)

SELLER SHALL ACKNOWLEDGE THIS DOCUMENT AS PROVIDED HEREIN REGARDLESS OF DOLLAR VALUE BY SIGNING AND RETURNING THE ENCLOSED SELLER ACKNOWLEDGEMENT COPY OF THIS DOCUMENT.

THE ABOVE NUMBERED PURCHASE ORDER IS MODIFIED AS SET FORTH ABOVE. EXCEPT AS PROVIDED HEREIN, ALL TERMS AND CONDITIONS OF THE SUBJECT PURCHASE ORDER REMAIN UNCHANGED AND IN FULL FORCE AND EFFECT.

9 1 1 0 2 5 1 2 1 1 9

J H Bourgeault 8/7/90

STATEMENT OF WORK FOR THE SINE PUMP FEATURE TESTS

1.0 INTRODUCTION

Investigations have identified several methods for the removal of wastes from 149 single shell waste tanks located at the Hanford Nuclear Reservation in south eastern Washington. One of the potential methods identified is a commercially available sine pump.

The completion of this testing will result in recommending retrieval methods for future development. This document discusses and defines the tasks to be performed to support the testing and evaluation of this technology.

2.0 OBJECTIVE

All feature testing shall be run with one pump a SINE, model SPS-50, using a 15 HP motor. The type A waste simulant (see section 4.0) should be pumped at 30 gpm at 125 psig and type B at 60 gpm at 125 psig. The suction head can be varied to evaluate pump performance with the simulant by adjusting the suction valve and reading the suction pressure gauge.

3.0 SCOPE

The scope of this task is not to optimize parameters, but to evaluate the feasibility of an "off the shelf" SINE pump to pump simulated sludge at prescribed flow rates. Actual test results will be compared to seller published statistical data.

4.0 TEST SIMULANT

4.1 SIMULANT DEVELOPMENT
All testing shall be performed using waste simulant developed by Westinghouse-Hanford Company (WHC). The simulants are still in development and may deviate slightly from the target values as indicated.

4.2 SLUDGE SIMULANT
The primary components of the sludge simulant will be bentonite clay, gravel, water and barium sulfate (a non-toxic, non-hazardous material). The rock material will simulate sludge chunks. The physical size of the rock will not be greater than specified in the vendor data. The criteria for the sludge simulants are type A the highest density and viscosity and type B a 1:1 dilution of sludge type A. The physical property target values for the two stimulants are as follows:

PROPERTIES	TARGET VALUES		DEVIATION
	TYPE A	TYPE B	
BULK DENSITY (g/ml)	1.6	1.3	±15%
VISCOSITY (cp)	1.7 million	40	±15%

revised 8-8-90

4.3 SIMULANT PROVIDED
WHC will provide 4-30 gallon drums of simulant type A and 8-30 gallon drums of simulant type B .

4.4 SIMULANT RESPONSIBILITIES

4.4.1 BUYER RESPONSIBILITIES
WHC will be the generator of record for the simulant when it is declared a waste product. The simulant will have material safety data sheets (MSDS) and will be classified non-hazardous when shipped to the seller. The used test medium will be re-analyzed before disposal to reaffirm its non-hazardous status.

4.4.2 SELLER RESPONSIBILITIES
The seller shall be responsible for the simulants while they are at the seller's test site. This includes assuring that the materials are not chemically contaminated, or replaced and the MSDS are maintained during this period. If the simulants are altered, WHC will not assume disposal responsibility. Containers of waste simulant for this test shall not be opened by the seller until ready for testing and shall be returned to the buyer as received except for the addition of potable water used in cleaning the system.

4.5 TRANSPORTATION/CLEAN-UP
The test simulant will be shipped to the seller's facility, Seattle Washington, just before testing. Each drum shipped will be labeled with a MSDS.

Additional empty Department of Transportation (DOT) approved drums will be sent for use in repackaging of the test simulant. After testing has been completed the simulants shall be cleaned out of the test equipment by the seller. The simulants shall not be altered except for the addition of potable water during the clean-up. The water addition shall be limited to doubling the buyer's furnished test simulant volume.

The simulant shall be repackaged into buyer furnished DOT approved containers and shipped by the seller to a location directed by WHC. WHC will pay actual shipping costs.

5.0 DESCRIPTION OF TEST

5.1 TEST METHOD
Seller shall prepare a test procedure which, at a minimum, shall cover:
a. how testing will be run.
b. what data will be collected and how.
c. schedule for work scope in weeks from purchase order award to completion of data summary.
d. detail information on and a schematic of the test loop.
e. detail information on pump to be tested.

revised 8-8-90

5.2 TEST SET UP
The seller's test loop shall, at a minimum, have:
a. discharge pressure indicator.
b. a method of measuring pressure/ head loss between pump discharge and the method of varying head loss.
c. suction pressure indicator.
d. a method of varying head loss.
e. a method of varying suction head.
f. a method of measuring flow rate.
g. a way of loading and supplying the test loop with simulant.

Attachment A provides the flow schematic which covers the above listed requirements.

5.3 RECORDING PARAMETERS
The following values shall be recorded by the seller during the feature testing:
a. Line pressure at suction of the pump.
b. Line pressure at discharge of the pump.
c. Line pressure at discharge of the pump loop immediately upstream of the control valve.
d. Flow rate of the system.
e. Motor horsepower.
f. Pump revolutions per minute.
g. Pump and loop leakage (visual).
h. Simulant temperature.
i. Voltage reading at the motor.
j. Amps draw at the motor.
The seller should test and record any other parameter they deem pertinent at no additional cost to the buyer.

During each test run the seller shall provide an in plant, on-site SINE Co. field engineer to support the total test program.

In the first test run each simulant shall be tested by the seller at 125 psi discharge pressure and a prescribed discharge flow rate (see section 2.0). The first test run shall vary the suction pressure from no restriction to a minus 10 psi in 2 psi intervals or until the pump stops pumping whichever comes first.

The second test shall vary the pump RPM from zero to the maximum RPM in 50 RPM steps and record data per section 5.3 . This is to be done with each simulant at a fixed discharged pressure of 125 psi.

In order to ensure the validity of testing, that it relates with other seller testing and to ensure a statistical value to the test, each of the tests should be done a minimum of three times.

revised 8-8-90

6.0 MANPOWER REQUIREMENTS

The seller shall provide all equipment, material (except simulant), SINE factory engineer for on site test support and other manpower as required to perform the testing program.

WHC personnel will observe the testing and act as witnesses for data verification and will record test activities using a video camera and photographic equipment.

7.0 REPORTING

A data summary for the feature testing shall be compiled by the seller in support of test activities. The data summary shall be in the form of a letter report. The summary shall include all parameter data requested in support of this test, as well as any observations witnessed during testing. Additional information within the summary should be limited to general notes discussing test outcome, suggestions for improvement and test conclusions. The limited scope of the feature testing does not require a full, in-depth test report.

Data included in the report shall also be accompanied by the method by which the value was obtained. i.e. direct measurement, calculation (include equation), etc. The accuracy of the recorded data shall also be included.

8.0 SAFETY

The seller shall insure that all activities pertaining to the preparation, completion and disposition of these activities shall be in accordance with local, state and federal codes, regulations and guidelines.

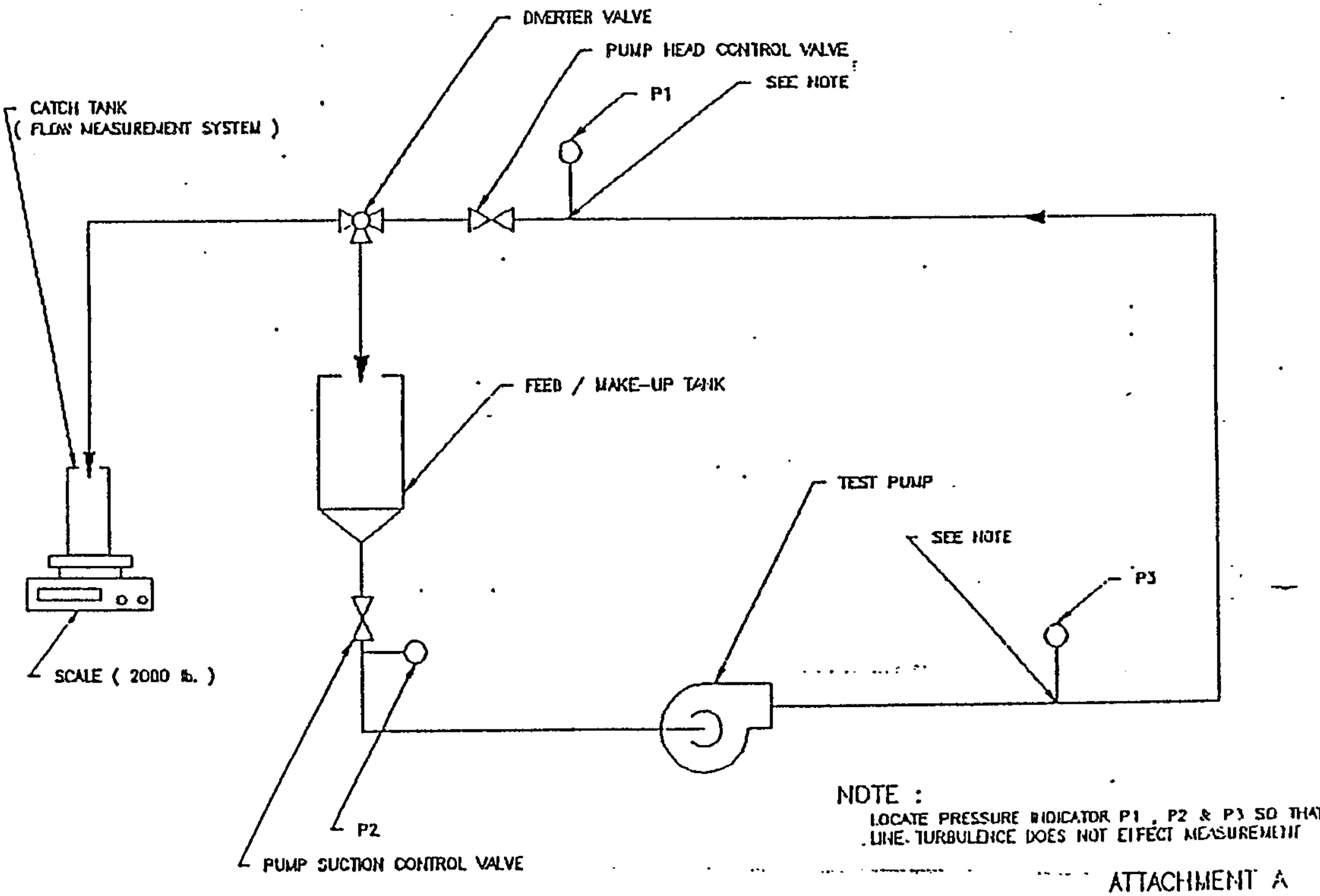
9.0 MILESTONES

ACTIVITIES	COMMITMENT DATE	RESPONSIBLE ORGANIZATION
Test Procedure Submittal	August 3	Seller
Ship Simulant to seller	August 10	WHC
Test Procedure Approval	August 10	WHC
Start Testing	August 20	Seller
Finish Testing	August 31	Seller
Data Summary Submittal	September 7	Seller
Ship Simulant to WHC	September 7	Seller
Data Summary Approval	September 14	WHC

All activities pertaining to this statement of work must be completed on or before September 14, 1990.

revised 8-8-90

Attachment A to
P.O. MBH-SVV-072554



ANALYSIS

PAGE ____
JOB NO. ____
DATE ____
BY ____
CHECKED BY ____

FOR ____
LOCATION ____
SUBJECT ____

Given: $1\ \frac{\text{gram}}{\text{Liter}} \times 0.008345 = 1\ \frac{\text{lb}}{\text{gal}}$

$$\left(1.3\ \frac{g}{\cancel{ml}}\right)\left(.008345\right)\left(1000\ \frac{ml}{L}\right) = 10.848\ \frac{lb}{gal} \qquad \text{TYPE B}$$

$$\left(1.6\ g/ml\right)\left(.008345\right)\left(1000\ \frac{ml}{L}\right) = 13.352\ \frac{lb}{gal} \qquad \text{TYPE A}$$

For a <u>10 second</u> diversion: (.1667 minutes)

$$\left(10.848\ \frac{lb}{gal}\right)\left(.1667\ \text{minutes}\right) = 1.8084\ \frac{lb \cdot min}{gal}$$

$$\boxed{\frac{\text{Number of Pounds Diverted (lbs)}}{1.8084\ \frac{lb \cdot min}{gal}} = GPM} \qquad \text{TYPE B}$$

$$\left(13.352\ \frac{lb}{gal}\right)\left(.1667\ \text{minutes}\right) = 2.2258\ \frac{lb \cdot min}{gal}$$

$$\boxed{\frac{\text{Number of Pounds Diverted (lbs)}}{2.2258\ \frac{lb \cdot min}{gal}} = GPM} \qquad \text{TYPE A}$$

A-7400-276 (9-87)

Attachment "D"

WESTINGHOUSE HANFORD

Sine Pump
Test Project

Beckwith & Kuffel Inc.
Job # 20-0431
August 1990

Attachment "E"

5930 1st Avenue South Seattle, Washington 98108

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1.0 INTRODUCTION

The Westinghouse Hanford Company (WHC) is investigating methods for the removal of waste from 149 single shell waste tanks located at the Hanford Nuclear Reservation. One of the potential methods identified is the Sine Pump.

This test will give WHC the information necessary to evaluate the feasibility of the Sine pump as a method for waste retrieval.

2.0 OBJECTIVES

The test must show that the Sine pump can meet the prescribed target specifications:

Pump type-A waste simulant at 30 GPM at 125 psig.

Pump type-B waste simulant at 60 GPM at 125 psig.

3.0 SCOPE

The scope of this test plan is not to optimize parameters, but to test the ability of the Sine Pump to pump simulated sludge at prescribed flow rates. This test will also compare actual results to statistical data.

4.0 DESCRIPTION OF TEST

4.1 Test Item - Sine Pump, Model SPS-50

4.2 Test Location - The testing will be executed at:

Beckwith and Kuffel, Inc.
5930 1st Ave. South
Seattle, WA 98108

4.3 Equipment and Facilities - The quantities and consistencies of the simulant wastes are as follows:

Simulant Type-A: Sludge, 4 - 30 Gallon drums
Simulant Type-B: 1:1 dilution of Type-A, 8 - 30 Gallon drums

The simulant waste will be provided by WHC.

The rate of wear of the pump software is unknown for the materials being pumped. The testing will require that spare software parts be available. (2 sets)

4.4 Instruments and Calibration

The test loop will be checked by running water through it to insure the proper function of the constituents.

The test loop is shown in Figure 1.

The loop consists of the following instruments:

1. Pump suction pressure gauge
2. Pump discharge pressure gauge
3. Flow control valve
4. Pressure gauge upstream of control valve
5. Temperature gauge
6. Motor starter and variable speed adjustment
7. Voltage reading across motor
8. Amps drawn by motor
9. Diverter valve
10. Suction control valve
11. Scale (2,000 lbs)

4.5 Simulants

	Density	/ Flow Rates	\	Viscosity	Volume
		Volumetric	Mass		
	(g/ml) (+/-15%)	(GPM)	(lbm/min) (+/-15%)	(cp) (+/-15%)	(gal)
Type-A	1.6	30	400	1,700,000	120
Type-B	1.3	60	650	40	240

5.0 TEST PROCEDURE

5.1 Test Method: The pump will be driven by a 15 HP motor for all tests. The pump suction head can be varied by adjusting the suction valve and reading the suction pressure gauge. The discharge pressure head can be adjusted by the flow control valve. A schematic of the test loop can be seen in Figure 1. Each test objective will be tested a minimum of three times. The pump suction pressure will be varied from no restriction to minus 10 psi in 2 psi increments or until the pump stops.

5.2 Procedure:

1. Fill out the data sheet header.
2. Calibrate the scale (#8) with the dry catch tank.
3. The line from the diverter valve C to the catch tank should be primed with simulant. (depends on length)
4. Close the loop with the diverter valve C.
5. Open the suction valve A completely.
6. Open the flow control valve B completely.
7. Start the motor and adjust the speed (#6) to approximately 600 RPM.
8. Adjust valve B until the pressure gauge #3 reads 125 psi.
9. Adjust the pump speed back to 600 RPM (#6).
10. The pump speed #6 and discharge pressure head #3 may need to be adjusted several times by valve B to meet the 125 psi and 600

RPM condition.

11. Read the voltage drop across the motor from #4.
12. Read the amperage drawn at the motor from #5.
13. Read pressure gauge #1.
14. Read pressure gauge #2. (should read >125 psi)
15. Read pressure gauge #3. (should read >125 psi)
16. Check for leakage from the pump or loop.
17. Record the temperature of the simultant from gauge #9.
18. Divert the simulant to the scale #8 for a prescribed time (in accordance to the mass flow rates given in section 4.5) by the diverter valve C. Then divert it back to the loop.
19. Record the mass of the simulant in the catch tank #8 and the time elapsed to flow the material into the catch tank #7.
20. Empty the contents of the catch tank back into the hopper.
21. Determine if the pump needs inspection according to Section 6.3.1.
22. Adjust the suction valve A until the pressure gauge #1 reads -2 psi.
23. Repeat Steps 8 through 21 for every -2 psi increment of the suction gauge #1 until the suction is -10 psi or the pump stops pumping.
24. Adjust the pump speed #6 down to zero RPM.
25. Increase the pump speed #6 by 50 RPM increments up to the maximum speed while keeping the discharge pressure at 125 psi.
26. At each 50 psi increment repeat steps 11 through 21.
27. Take a sample of the simulant, lable it, and record the number on the data sheet.
28. This procedure should be repeated 3 times for each simulant.

6.0 <u>MAINTENANCE AND FAILURES</u>

6.1 <u>PUMP PARTS TO DISASSEMBLE</u>

Hardware - Front Cover
- Shaft Nut
- Rotor
- Scraper Gate Guide

Software - Front and Rear Liners
- Scraper Gate
- Scraper Gate Support
- Lip Seal Housing
- Shaft Sleeve

6.2 <u>DISASSEMBLING INSTRUCTIONS</u>

1. Remove front cover nuts
2. Remove front cover
3. Remove scraper gate support
4. Remove front liner
5. Remove shaft nut

6. Remove rotor with scraper gate assembly
7. Remove rear liner
8. Remove shaft sleeve
9. Remove lip seal housing

6.3 INSPECTION

6.3.1 Inspection of the Sine Pump parts will occur under the following conditions.

1. Before testing begins, to make initial measurements and observations
2. The test procedure has been successfully executed for an entire simulant type
3. The pump stops pumping
4. Under other conditions in which the testing engineers deem it necessary

6.3.2 The following observations/measurements should be taken during each inspection and recorded on data sheet.

1. General overall observation of wear on parts (hardware and software)
2. Micrometer measurements of the width of the scraper gate slot
3. Micrometer measurements of the width and thickness of the scraper gate
4. Measurements of the front and rear liner dimensions that are subject to wear
5. Measure wall thickness of scraper gate support
6. Measure wall thickness of lip seal housing

6.3.3 If the pump stops or wear is substantially affecting the performance of the pump then the pump software may need to be replaced. Replacement will occur:

1. The pump stops functioning as a result of wear.
2. The performance of the pump is so obviously affected by wear that the data taken is unusable.

7.0 WITNESSES

A representative of WHC will witness and record the entire test procedure.

8.0 SCHEDULE

ACTIVITIES	COMMITMENT DATE
Test Procedure Approval	August 10
Start testing	August 20
Finish testing	August 31
Data summary submittal	September 7
Shipping Simulant to WHC	September 7
Data summary approval	September 14

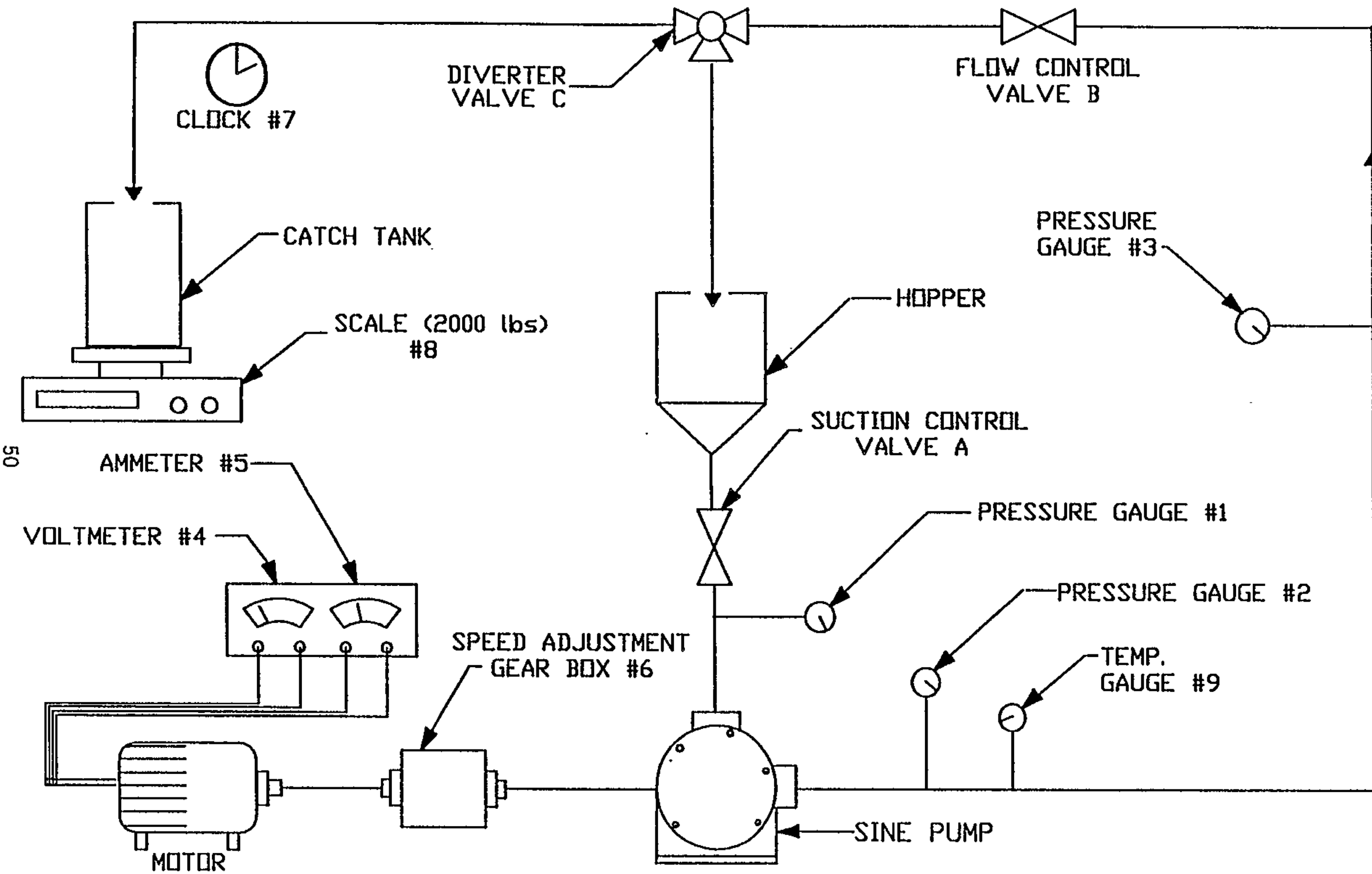

Figure 1. Test loop for Sine pump feature testing.

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DATA SHEET

TEST ITEM: Sludge Simulant SIMULANT TYPE: B

DATE: 8/28/90 TEST RUN NUMBER: B-1

TEST ENGINEERS: K. Squires
D. Ruff

SIMULANT SAMPLE NUMBER: ________

NOMINAL SUCTION (psi)	0	-2	-4	-6	-8	-10
PRESSURE GAUGE 1 (psi)	125	125	125	125	125	125
PRESSURE GAUGE 2 (psi)	—	—	—	—	—	—
PRESSURE GAUGE 3 (psi)	—	—	—	—	—	—
MOTOR VOLTAGE 4 (V)	107	150	150	160	153	150
MOTOR AMPERAGE 5 (A)	140	150	150	150	145	150
MOTOR SPEED 6 (RPM)	350	366	372	375	372	355
DIVERSION TIME 7 (SECS)	10	10	10	5 *	10	10
(gpm) DIVERTED MASS 8 (lbm)	(59.2) 107	(65.8) 119	(63.6) 115	(86.2) 78	(70.7) 128	(44.7) 81
SIMULANT TEMP. 9 (F)	109°	105°	111°	—	90°	101°
BHP	20.08	30.16	30.16	32.17	29.74	30.16

* ESTIMATED

Exhibit B-1-1

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: B

DATE: 8/28/90

TEST RUN NUMBER: B-1

TEST ENGINEERS: K. Squires
D. Ruff

SIMULANT SAMPLE NUMBER: ______

PUMP SPEED (RPM)	50	100	150	200	250	300
PRESSURE GAUGE 1 (psi)	—	0	0	0	0	125
PRESSURE GAUGE 2 (psi)	—	—	—	—	—	—
PRESSURE GAUGE 3 (psi)	—	—	—	—	—	—
MOTOR VOLTAGE 4 (V)	—	12	20	30	40	135
MOTOR AMPERAGE 5 (A)	—	8	10	14	20	140
MOTOR SPEED 6 (RPM)	—	95	148	202	257	304
DIVERSION TIME 7 (SECS)	—	10	10	10	10	10
(gpm) DIVERTED MASS 8 (lbm)	—	(49.2) 89	(69.1) 125	(87.3) 158	(103.4) 187	(29.3) 53
SIMULANT TEMP. 9 (F)	—	81°	—	75°	—	75°
BHP		.129	.268	.563	1.07	25.34

DATA SHEET

TEST ITEM: Sludge Simulant SIMULANT TYPE: B

DATE: 8/28/90 TEST RUN NUMBER: B-1

TEST ENGINEERS: K. Squires
D. Ruff SIMULANT SAMPLE NUMBER: ________

PUMP SPEED (RPM)	350	400	450	500	550	600
PRESSURE GAUGE 1 (psi)	125	125	125	125	—	—
PRESSURE GAUGE 2 (psi)	—	—	—	—	—	—
PRESSURE GAUGE 3 (psi)	—	—	—	—	—	—
MOTOR VOLTAGE 4 (V)	145	155	175	190	—	—
MOTOR AMPERAGE 5 (A)	140	135	135	135	—	—
MOTOR SPEED 6 (RPM)	354	403	450	500	—	—
DIVERSION TIME 7 (SECS)	10	10	10	10	—	—
(gpm) DIVERTED MASS 8 (lbm)	(42.6) 77	(52.5) 95	(92.9) 168	(113.9) 206	—	—
SIMULANT TEMP. 9 (F)	83°	88°	83°	—	—	—
BHP	27.21	28.05	31.67	34.38		

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: B

DATE: 8/29/90

TEST RUN NUMBER: B-2

TEST ENGINEERS: K. Squires
D. Ruff
D. Wanner

SIMULANT SAMPLE NUMBER: ______

NOMINAL SUCTION (psi)	0	-2	-4	-6	-8	-10
PRESSURE GAUGE 1 (psi)	125	125	125	125	125	125
PRESSURE GAUGE 2 (psi)	—	—	—	—	—	—
PRESSURE GAUGE 3 (psi)	—	—	—	—	—	—
MOTOR VOLTAGE 4 (V)	140	140	—	140	140	140
MOTOR AMPERAGE 5 (A)	140	140	—	145	145	140
MOTOR SPEED 6 (RPM)	348	348	346	349	349	349
DIVERSION TIME 7 (SECS)	10	10	10	10	10	10
DIVERTED MASS 8 (lbm) (gpm)	(27.2) 49	(21.5) 39	(22.1) 40	(18.8) 34	(21.0) 38	—
SIMULANT TEMP. 9 (F)	80°	—	86°	85°	—	105°
BHP	26.27	26.27		27.21	27.21	26.27

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: B

DATE: 8/29/90

TEST RUN NUMBER: B-2

TEST ENGINEERS: K. Squires
D. Rufe
D. Wanner

SIMULANT SAMPLE NUMBER:

PUMP SPEED (RPM)	50	100	150	200	250	300
PRESSURE GAUGE 1 (psi)	—	0	—	0	—	125
PRESSURE GAUGE 2 (psi)	—	—	—	—	—	—
PRESSURE GAUGE 3 (psi)	—	—	—	—	—	—
MOTOR VOLTAGE 4 (V)	—	15	—	30	—	125
MOTOR AMPERAGE 5 (A)	—	15	—	20	—	135
MOTOR SPEED 6 (RPM)	—	114	—	202	—	309
DIVERSION TIME 7 (SECS)	—	10	—	10	—	10
(gpm) DIVERTED MASS 8 (lbm)	—	(30.4) 55	—	(89.0) 161	—	(1.6) 3
SIMULANT TEMP. 9 (F)	—	—	—	101°	—	85°

BHP .30 .80 22.62

Exhibit B-2-2

9 1 1 2 5 2 0 4 1 6

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: B

DATE: 8/29/90

TEST RUN NUMBER: B-2

TEST ENGINEERS: K. Squires
D. Ruff
D. Wanner

SIMULANT SAMPLE NUMBER: ______

PUMP SPEED (RPM)	350	400	450	500	550	600
PRESSURE GAUGE 1 (psi)	125					
PRESSURE GAUGE 2 (psi)	—					
PRESSURE GAUGE 3 (psi)	—					
MOTOR VOLTAGE 4 (V)	140					
MOTOR AMPERAGE 5 (A)	135					
MOTOR SPEED 6 (RPM)	357					
DIVERSION TIME 7 (SECS)	10					
(GPM) DIVERTED MASS 8 (lbm)	(29.8) 54					
SIMULANT TEMP. 9 (F)	—					

BHP 25.34

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: B

DATE: 8/30/90

TEST RUN NUMBER: B-1

TEST ENGINEERS: K. Squires
D. Ruff
D. Wamner

SIMULANT SAMPLE NUMBER: ______

NOMINAL SUCTION (psi)	0	-2	-4	-6	-8	-10
PRESSURE GAUGE 1 (psi)	125	125	125	125	125	125
PRESSURE GAUGE 2 (psi)	—	—	—	—	—	—
PRESSURE GAUGE 3 (psi)	—	—	—	—	—	—
MOTOR VOLTAGE 4 (V)	135	140	140	140	140	140
MOTOR AMPERAGE 5 (A)	140	140	145	145	145	140
MOTOR SPEED 6 (RPM)	352	352	352	352	352	351
DIVERSION TIME 7 (SECS)	10	10	10	10	10	10
(GPM) DIVERTED MASS 8 (lbm)	(17.7) 32	(23.3) 43	(20.4) 37	(19.9) 36	(18.2) 33	(15.5) 28
SIMULANT TEMP. 9 (F)	73°	—	—	—	—	—
BHP	25.34	26.27	27.21	27.21	27.21	26.27

Exhibit B-3-1

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: B

DATE: 8/30/90

TEST RUN NUMBER: B-3

TEST ENGINEERS: K. Squires
D. Ruff
D. Wamner

SIMULANT SAMPLE NUMBER: ______

PUMP SPEED (RPM)	50	100	150	200	250	300
PRESSURE GAUGE 1 (psi)					0	125
PRESSURE GAUGE 2 (psi)					—	—
PRESSURE GAUGE 3 (psi)					—	—
MOTOR VOLTAGE 4 (V)					40	120
MOTOR AMPERAGE 5 (A)					25	130
MOTOR SPEED 6 (RPM)					256	305
DIVERSION TIME 7 (SECS)					10	10
gpm) DIVERTED MASS 8 (lbm)					(108.9) 197	(6.6) 12
SIMULANT TEMP. 9 (F)						—
BHP					1,34	20.91

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: B

DATE: 8/30/90

TEST RUN NUMBER: B-3

TEST ENGINEERS: K. Squires
D. Ruff
D. Wanner

SIMULANT SAMPLE NUMBER: ______

PUMP SPEED (RPM)	350	400	450	500	550	600
PRESSURE GAUGE 1 (psi)	125	125	125	125		
PRESSURE GAUGE 2 (psi)	—	—	—	—		
PRESSURE GAUGE 3 (psi)	—	—	—	—		
MOTOR VOLTAGE 4 (V)	135	150	170	185		
MOTOR AMPERAGE 5 (A)	140	130	135	130		
MOTOR SPEED 6 (RPM)	356	406	453	500		
DIVERSION TIME 7 (SECS)	10	10	10	10		
(gpm) DIVERTED MASS 8 (lbm)	(31.0) 56	(56.9) 103	(73.0) 132	(96.2) 174		
SIMULANT TEMP. 9 (F)	—	—	—			
BHP	25.34	26.14	30.76	32.24		

0 1 0 2 5 1 1 6

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/31/90

TEST RUN NUMBER: A-1

TEST ENGINEERS: K. Squires
D. Wanner

SIMULANT SAMPLE NUMBER:

NOMINAL SUCTION (psi)	0	-2	-4	-6	-8	-10
PRESSURE GAUGE 1 (psi)			125	125	125	
PRESSURE GAUGE 2 (psi)			—	—	—	
PRESSURE GAUGE 3 (psi)			—	—	—	
MOTOR VOLTAGE 4 (V)			150	150	150	
MOTOR AMPERAGE 5 (A)			160	160	170	
MOTOR SPEED 6 (RPM)			346	349	347	
DIVERSION TIME 7 (SECS)			10	10	10	
(GPM) DIVERTED MASS 8 (lbm)			(53.0) 118	(51.7) 115	(49.9) 111	
SIMULANT TEMP. 9 (F)			94°	98°	—	
BHP			32.17	32.17	34.18	

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/30/90; 8/31/90

TEST RUN NUMBER: A-1

TEST ENGINEERS: K. Squires.
D. Ruff
D. Wamner

SIMULANT SAMPLE NUMBER:

PUMP SPEED (RPM)	50	100	150	200	250	300
PRESSURE GAUGE 1 (psi)		0	0	100	100	122
PRESSURE GAUGE 2 (psi)		—	—	—	—	—
PRESSURE GAUGE 3 (psi)		—	—	—	—	—
MOTOR VOLTAGE 4 (V)		35	50	60	75	90
MOTOR AMPERAGE 5 (A)		75	65	90	70	70
MOTOR SPEED 6 (RPM)		105	153	199	249	302
DIVERSION TIME 7 (SECS)		10	10	10	10	10
(gpm) DIVERTED MASS 8 (lbm)		—	(18.9) 42	(16.2) 36	(38.6) 86	(42.2) 94
SIMULANT TEMP. 9 (F)			85°	82°	71°	—
BHP		3.52	4.36	7.24	7.4	8.45

Exhibit A-1-2

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/30/90; 8/31/90

TEST RUN NUMBER: A-1

TEST ENGINEERS: K. Squires
D. Ruff
D. Wanner

SIMULANT SAMPLE NUMBER: ______

PUMP SPEED (RPM)	350	400	450	500	550	600
PRESSURE GAUGE 1 (psi)	48	125				
PRESSURE GAUGE 2 (psi)	—	—				
PRESSURE GAUGE 3 (psi)	—	—				
MOTOR VOLTAGE 4 (V)	100	165				
MOTOR AMPERAGE 5 (A)	75	150				
MOTOR SPEED 6 (RPM)	350	400				
DIVERSION TIME 7 (SECS)	10	10				
(gpm) DIVERTED MASS 8 (lbm)	(55.7) 124	(52.6) 117				
SIMULANT TEMP. 9 (F)	—	76°				

BHP 10.7 33.18

9112152043

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/31/90

TEST RUN NUMBER: A-2

TEST ENGINEERS: K. Squires
D. Wamner

SIMULANT SAMPLE NUMBER: ______

NOMINAL SUCTION (psi)	0	-2	-4	-6	-8	-10
PRESSURE GAUGE 1 (psi)			125	125	125	
PRESSURE GAUGE 2 (psi)			—	—	—	
PRESSURE GAUGE 3 (psi)			—	—	—	
MOTOR VOLTAGE 4 (V)			150	150	150	
MOTOR AMPERAGE 5 (A)			160	180	170	
MOTOR SPEED 6 (RPM)			352	346	350	
DIVERSION TIME 7 (SECS)			10	10	10	
DIVERTED MASS 8 (lbm) (gpm)			(38.2) 85	(30.6) 68	(37.3) 83	
SIMULANT TEMP. 9 (F)			—	94°	95°	

BHP 32.17 36.19 34.18

Exhibit A-2-1

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/31/90

TEST RUN NUMBER: A-2

TEST ENGINEERS: K. Squires
D. Wanner

SIMULANT SAMPLE NUMBER: ________

PUMP SPEED (RPM)	50	100	150	200	250	300
PRESSURE GAUGE 1 (psi)			0	60	85	110
PRESSURE GAUGE 2 (psi)			—	—	—	—
PRESSURE GAUGE 3 (psi)			—	—	—	—
MOTOR VOLTAGE 4 (V)			50	60	75	90
MOTOR AMPERAGE 5 (A)			90	75	75	80
MOTOR SPEED 6 (RPM)			148	206	251	299
DIVERSION TIME 7 (SECS)			10	10	10	10
(gpm) DIVERTED MASS 8 (lbm)			(10.3) 23	(22.4) 51	(44.0) 98	(58.9) 131
SIMULANT TEMP. 9 (F)			—	69°	69°	70°
BHP			6.3	6.3	7.54	9.65

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/31/90

TEST RUN NUMBER: A-2

TEST ENGINEERS: K. Squires
D. Wanner

SIMULANT SAMPLE NUMBER:

PUMP SPEED (RPM)	350	400	450	500	550	600
PRESSURE GAUGE 1 (psi)	125	125				
PRESSURE GAUGE 2 (psi)	—	—				
PRESSURE GAUGE 3 (psi)	—	—				
MOTOR VOLTAGE 4 (V)	150	165				
MOTOR AMPERAGE 5 (A)	170	180				
MOTOR SPEED 6 (RPM)	349	388				
DIVERSION TIME 7 (SECS)	10	10				
(gpm) DIVERTED MASS 8 (lbm)	(46.3) 103	(61.1) 136				
SIMULANT TEMP. 9 (F)	—	77°				

BHP 34.18 39.81

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/31/90

TEST RUN NUMBER: A-3

TEST ENGINEERS: K. Squires
D. Wanner

SIMULANT SAMPLE NUMBER: ________

NOMINAL SUCTION (psi)	0	-2	-4	-6	-8	-10
PRESSURE GAUGE (psi) 1			125	125	125	
PRESSURE GAUGE (psi) 2			—	—	—	
PRESSURE GAUGE (psi) 3			—	—	—	
MOTOR VOLTAGE (V) 4			150	155	150	
MOTOR AMPERAGE (A) 5			160	170	180	
MOTOR SPEED (RPM) 6			354	348	358	
DIVERSION TIME (SECS) 7			10	10	10	
(gpm) DIVERTED MASS (lbm) 8			(41.8) 93	(40.0) 89	(27.0) 60	
SIMULANT TEMP. (F) 9			—	—	112°	
BHP			32.18	35.32	36.19	

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/31/90

TEST RUN NUMBER: A-3

TEST ENGINEERS: K. Squires
D. Wamner

SIMULANT SAMPLE NUMBER: ______

PUMP SPEED (RPM)	50	100	150	200	250	300
PRESSURE GAUGE 1 (psi)			0	90	123	125
PRESSURE GAUGE 2 (psi)			—	—	—	—
PRESSURE GAUGE 3 (psi)			—	—	—	—
MOTOR VOLTAGE 4 (V)			50	65	115	135
MOTOR AMPERAGE 5 (A)			70	75	160	160
MOTOR SPEED 6 (RPM)			155	204	253	307
DIVERSION TIME 7 (SECS)			10	10	10	10
gpm) DIVERTED MASS 8 (lbm)			(7.6) 17	(26.1) 58	(17.5) 39	(37.7) 84
SIMULANT TEMP. 9 (F)			—	93°	—	104°
BHP			4.69	6.53	24.66	28.95

DATA SHEET

TEST ITEM: Sludge Simulant

SIMULANT TYPE: A

DATE: 8/31/90

TEST RUN NUMBER: A-3

TEST ENGINEERS: K. Squires
D. Wanner

SIMULANT SAMPLE NUMBER: ______

PUMP SPEED (RPM)	350	400	450	500	550	600
PRESSURE GAUGE 1 (psi)	125	125				
PRESSURE GAUGE 2 (psi)	—	—				
PRESSURE GAUGE 3 (psi)	—	—				
MOTOR VOLTAGE 4 (V)	155	175				
MOTOR AMPERAGE 5 (A)	180	180				
MOTOR SPEED 6 (RPM)	349	398				
DIVERSION TIME 7 (SECS)	10	10				
(gpm) DIVERTED MASS 8 (lbm)	(46.7) 104	(60.2) 134				
SIMULANT TEMP. 9 (F)	99°	101°				

BHP 37.40 42.23

9 1 1 2 9 5 2 0 1 1 9

SHAFT SLEEVE

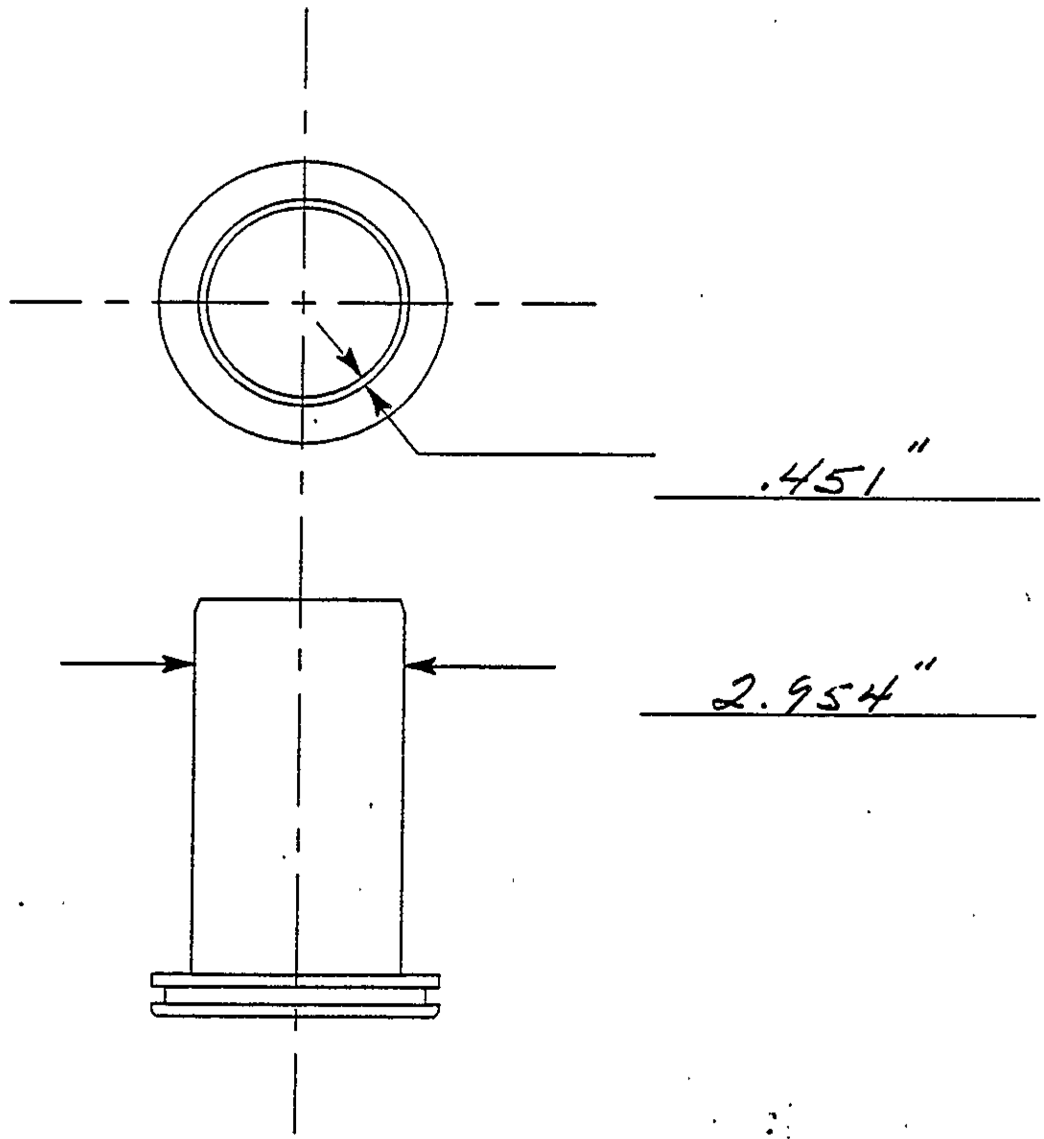
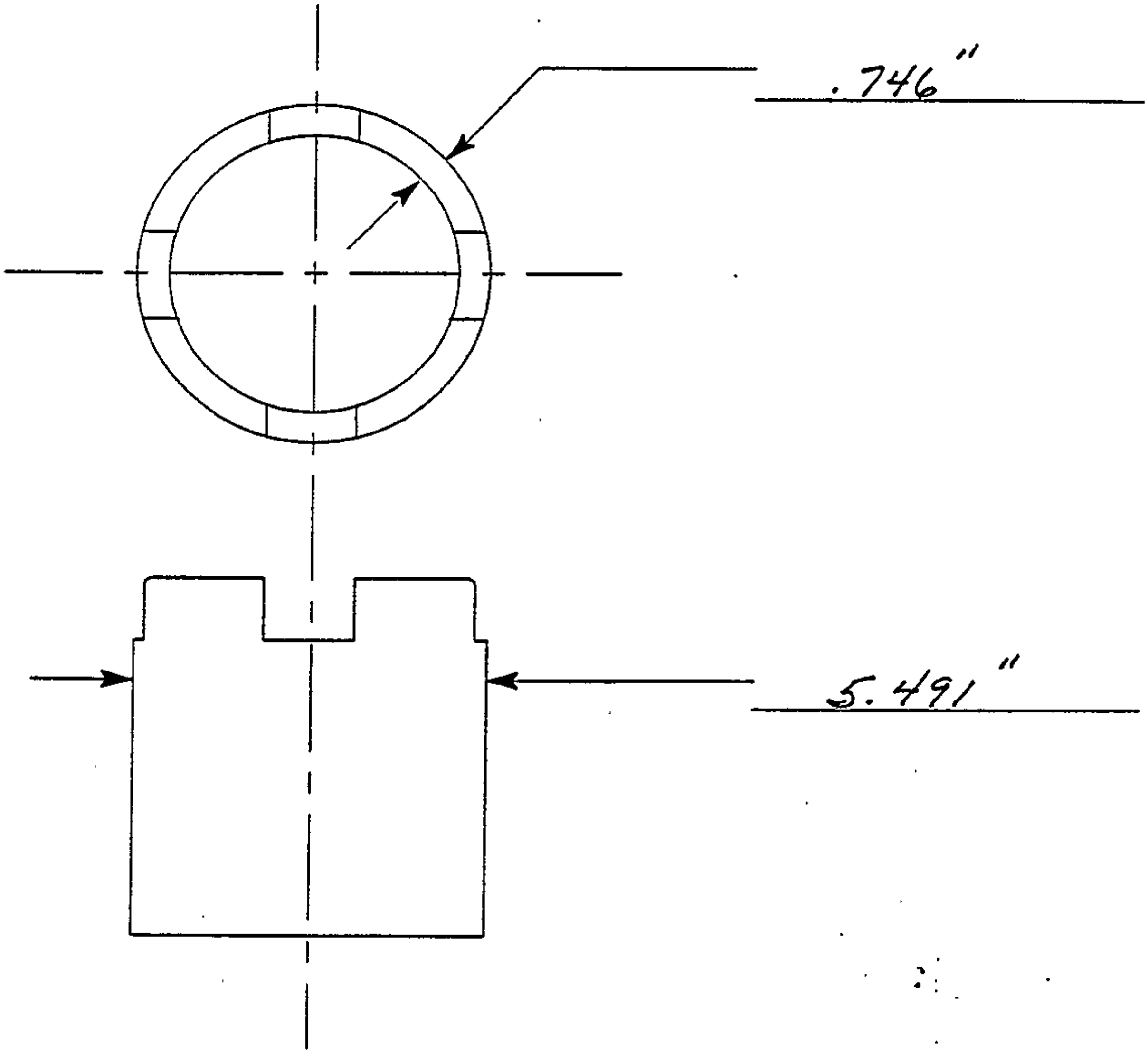
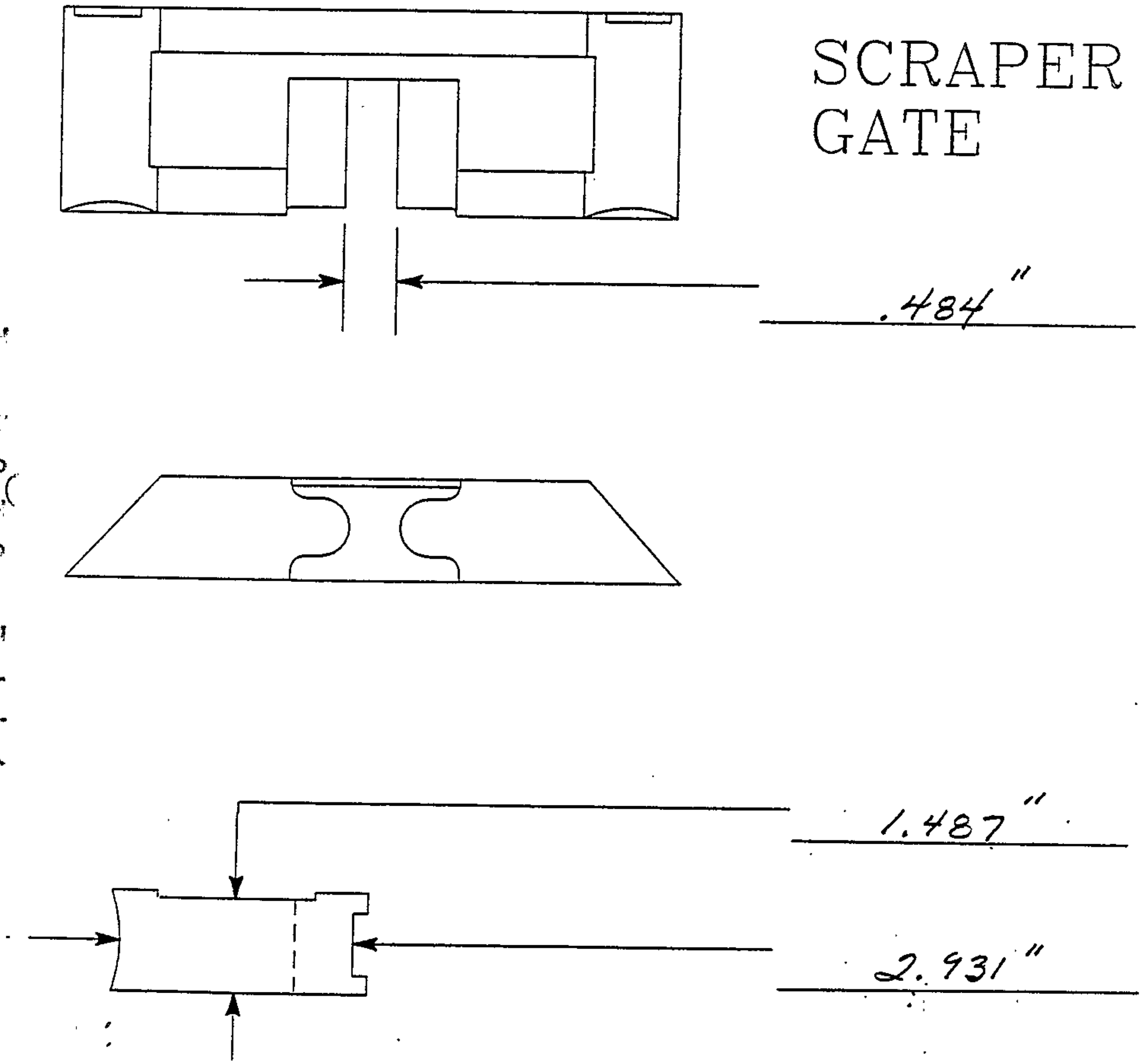


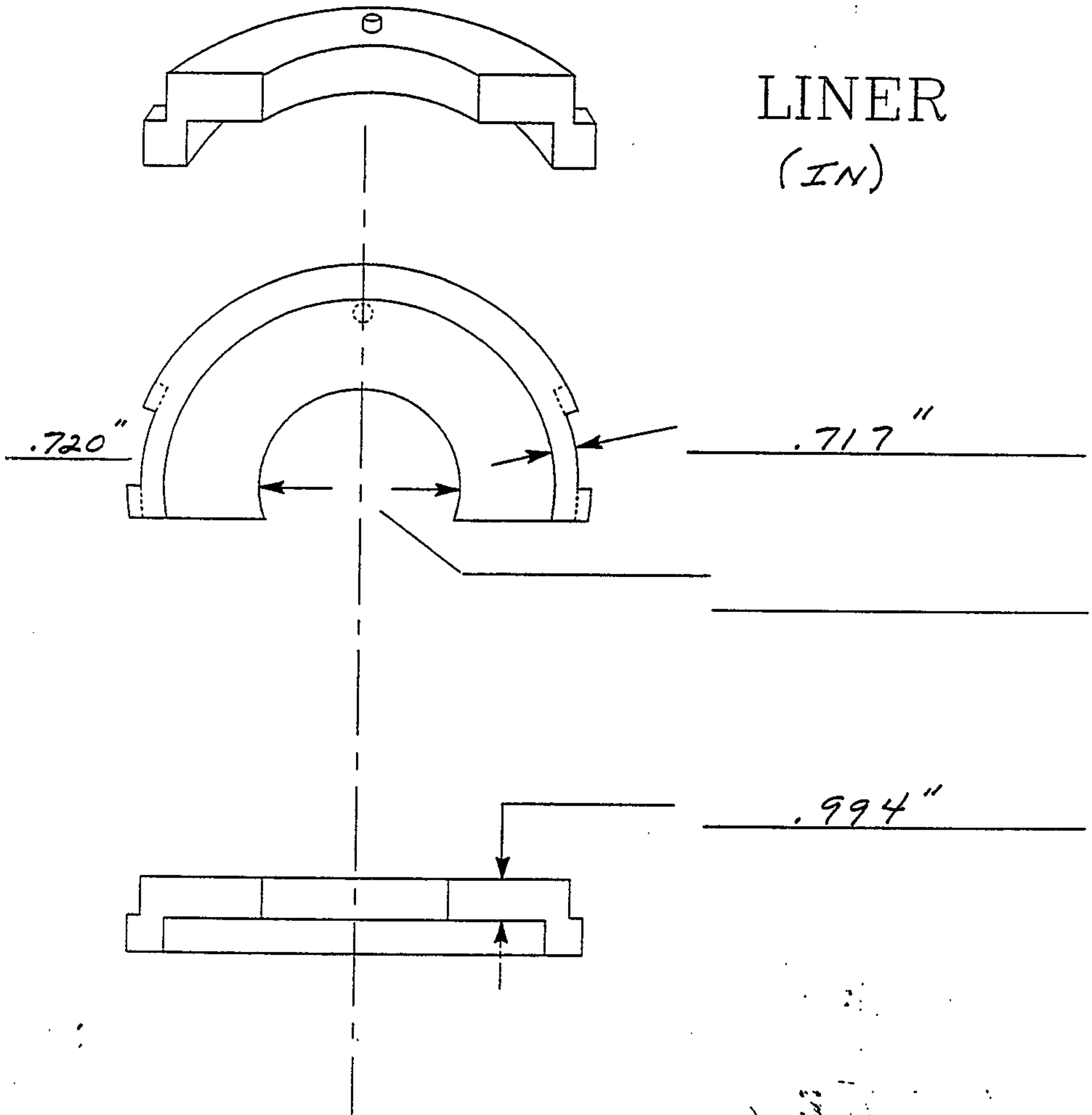
Exhibit 4

SCRAPER GATE SUPPORT



SCRAPER GATE

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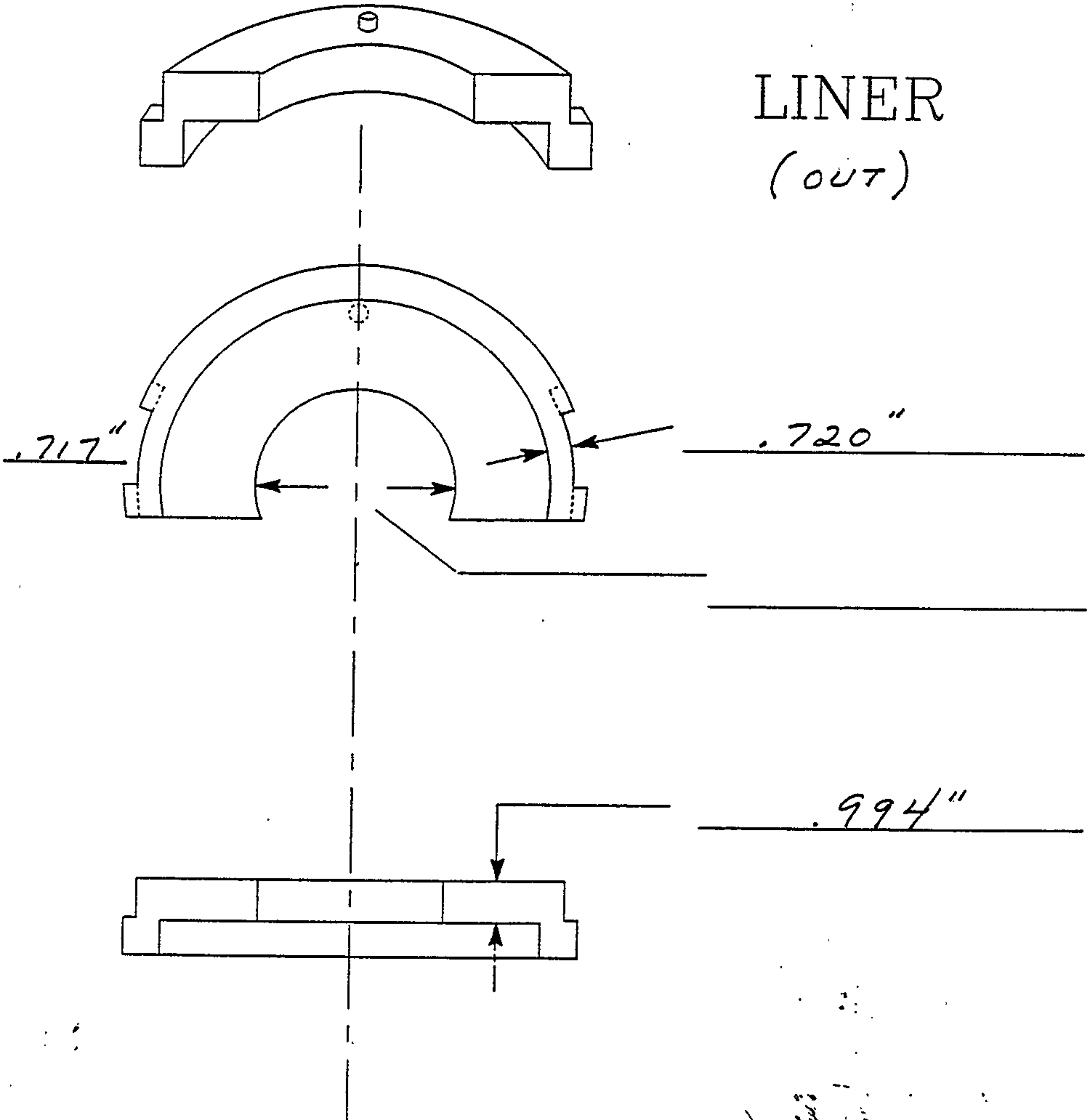

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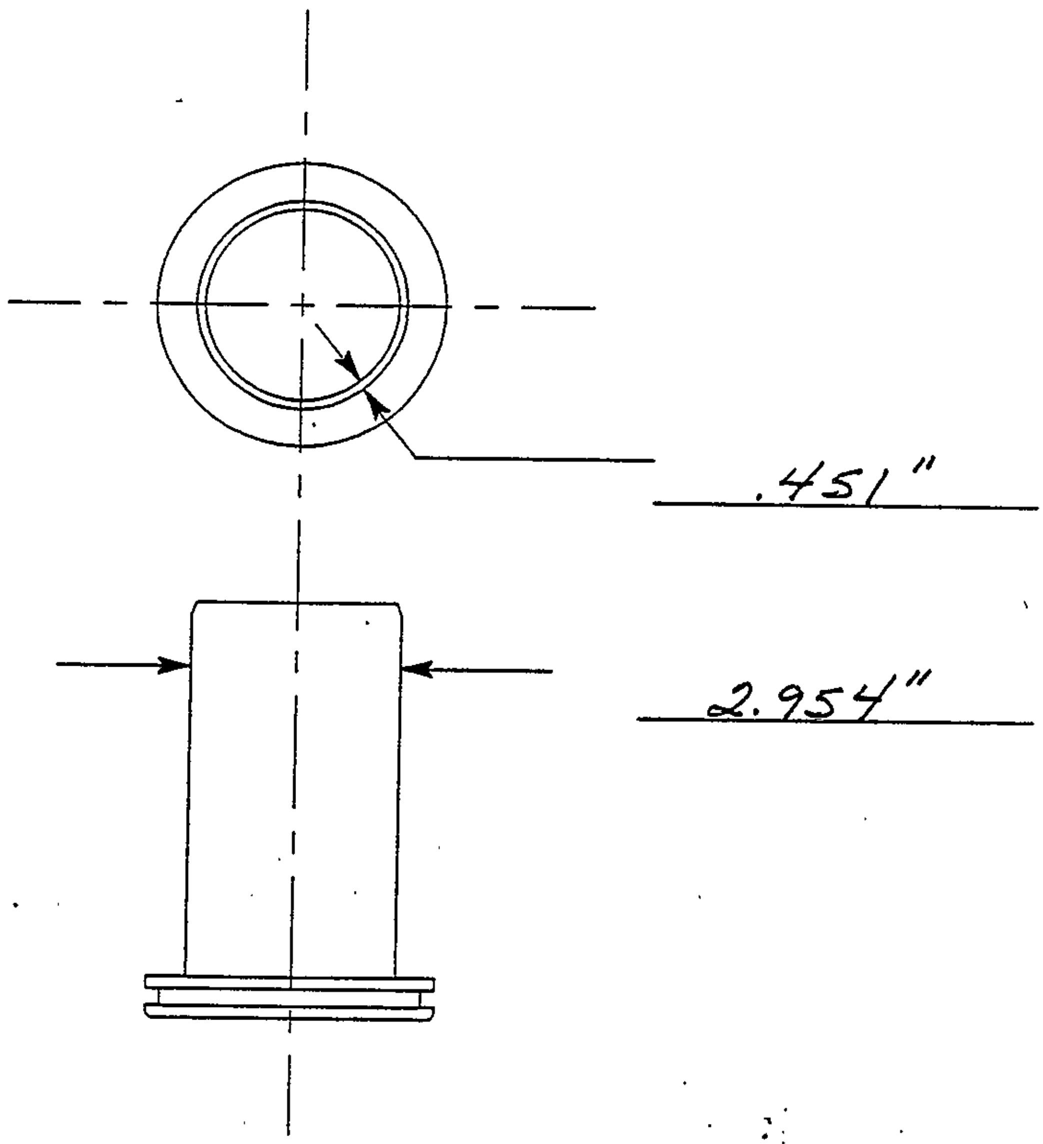
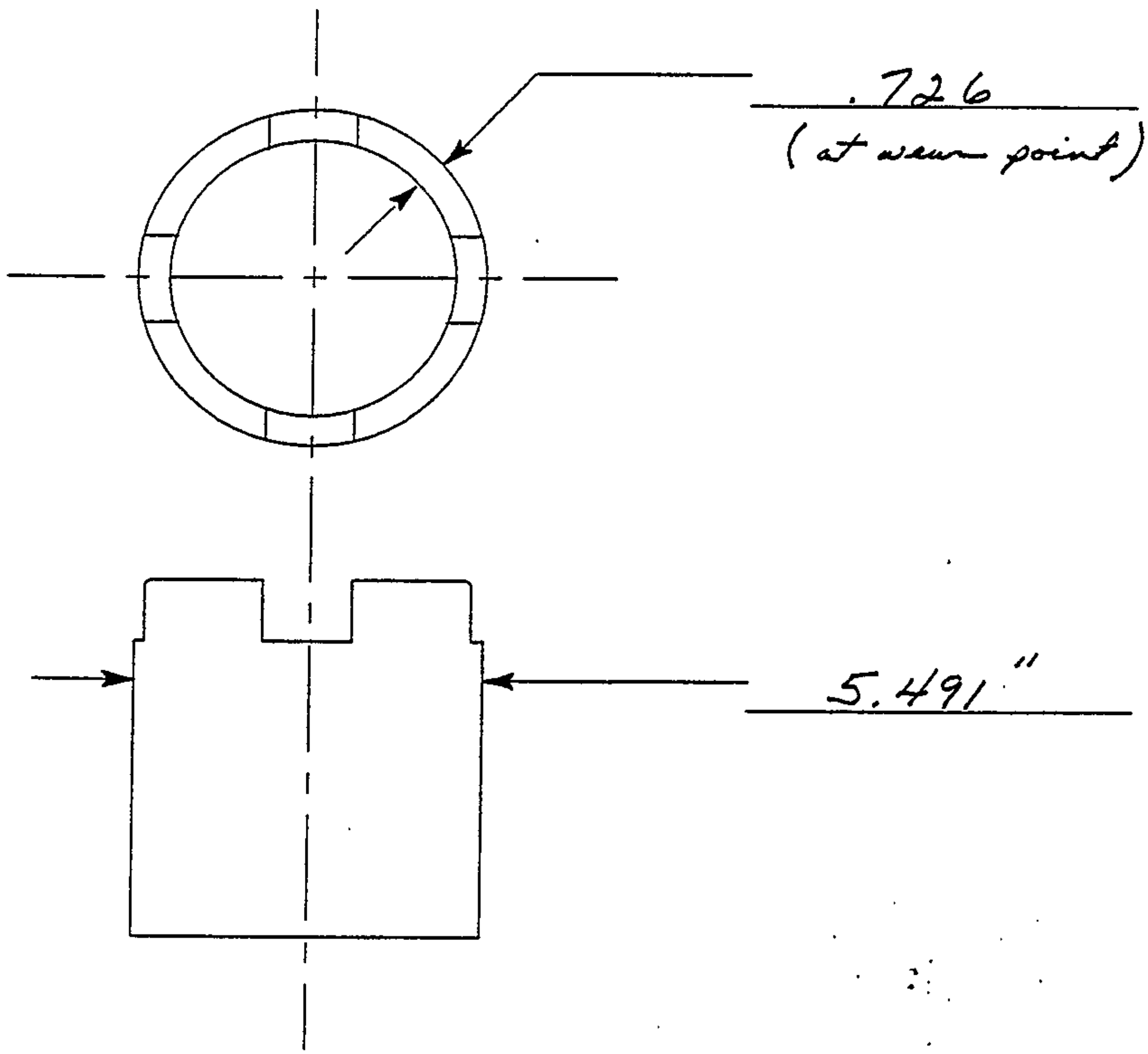


Exhibit 5

SCRAPER GATE SUPPORT



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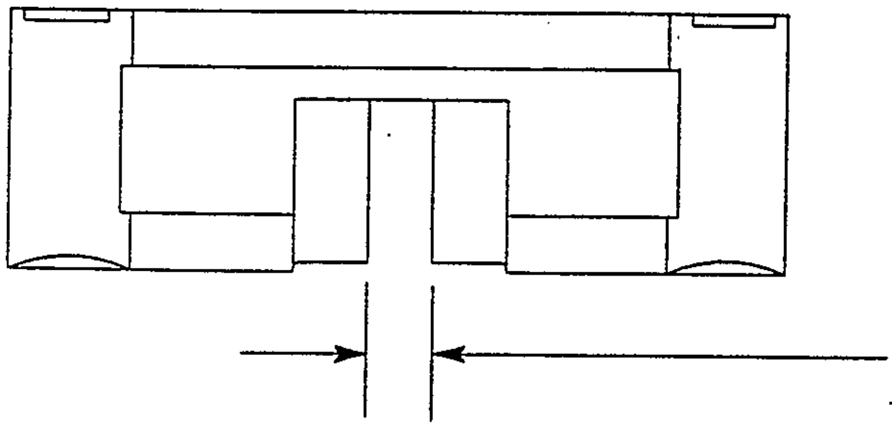

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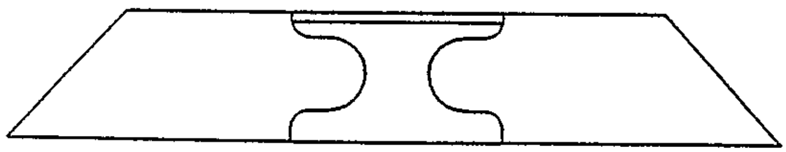
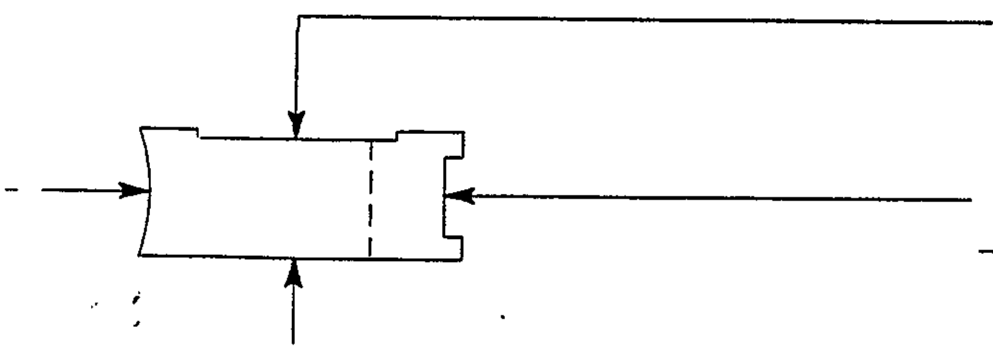


Slight scoring & pitting



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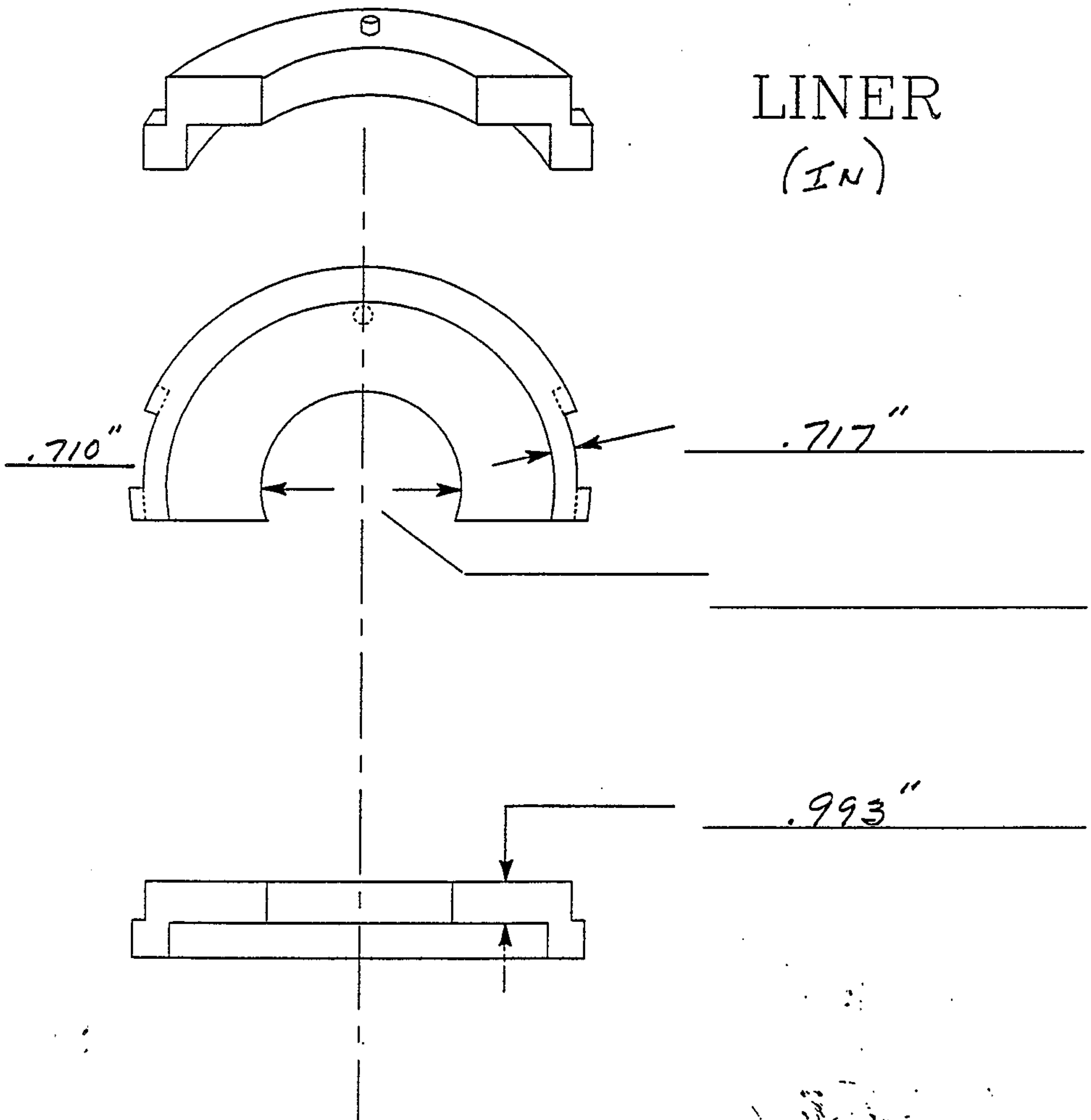
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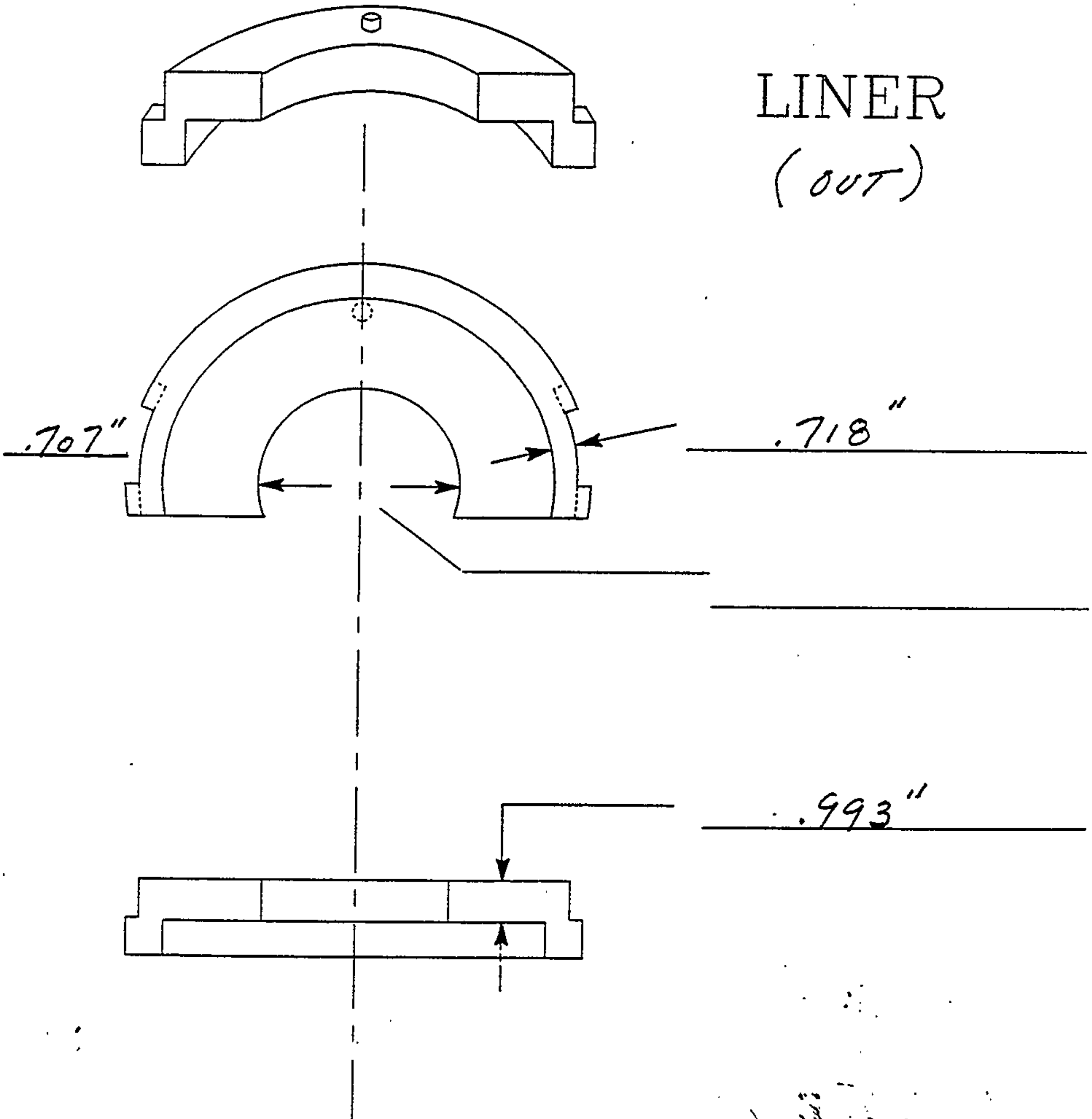
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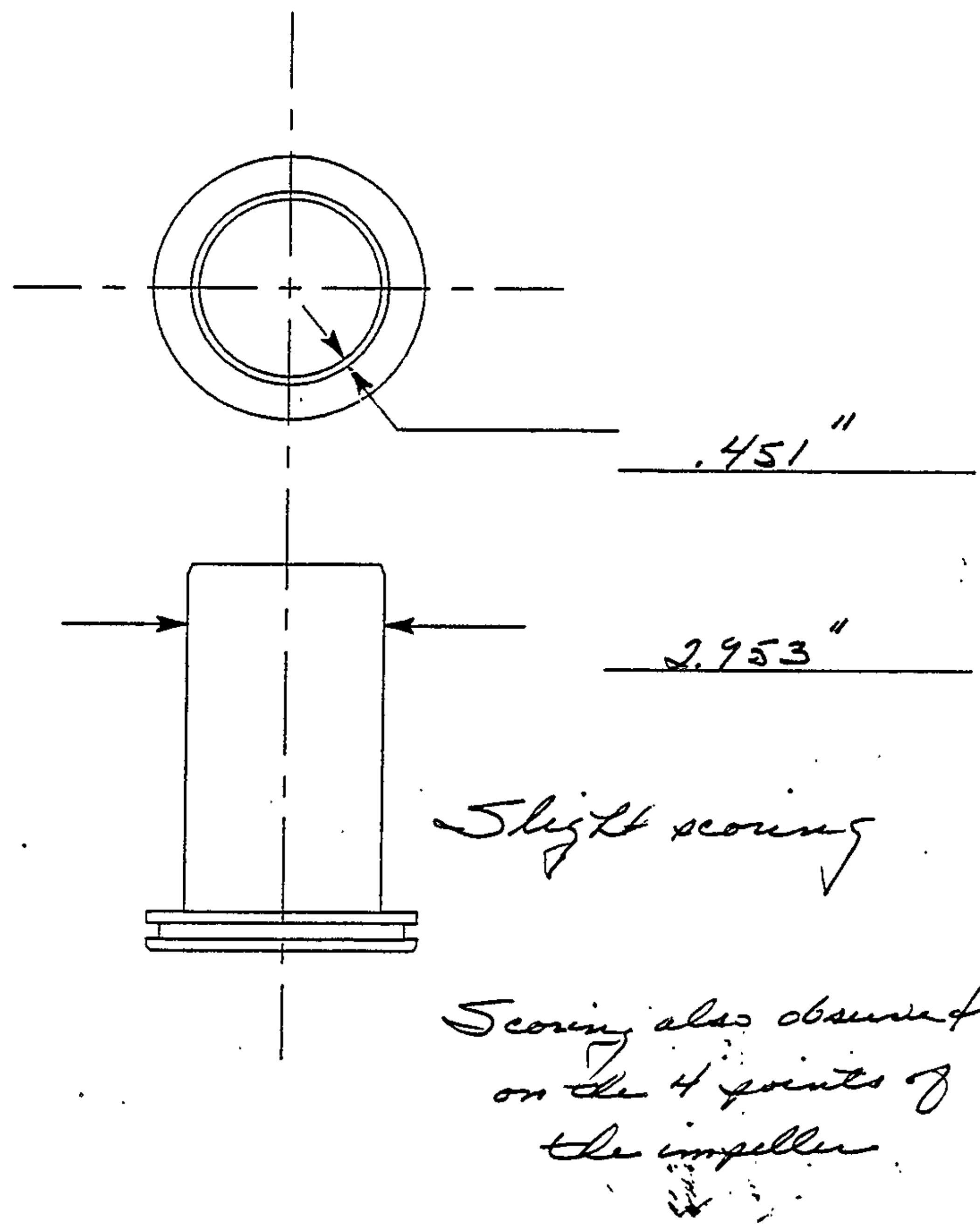
SHAFT SLEEVE



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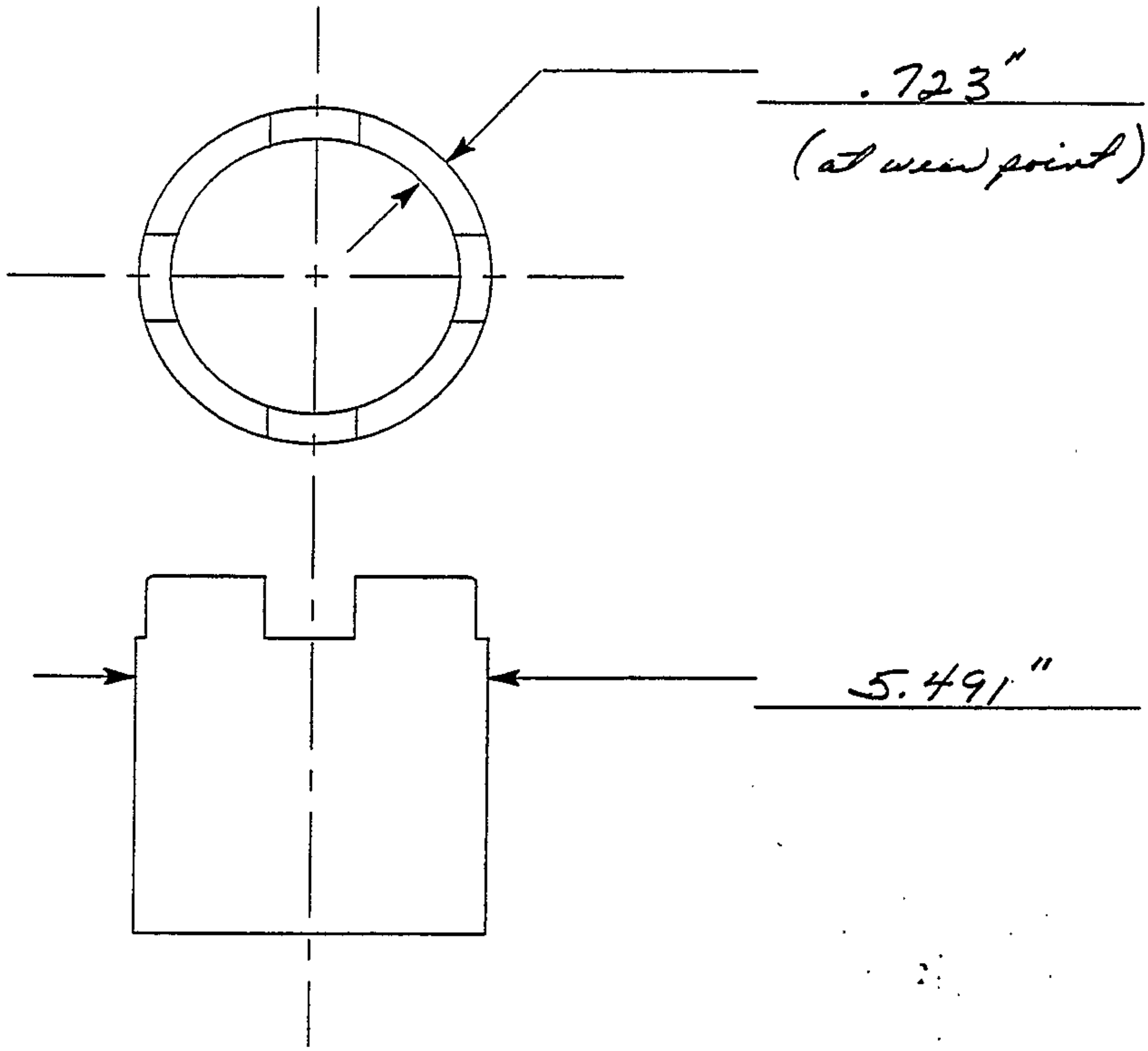

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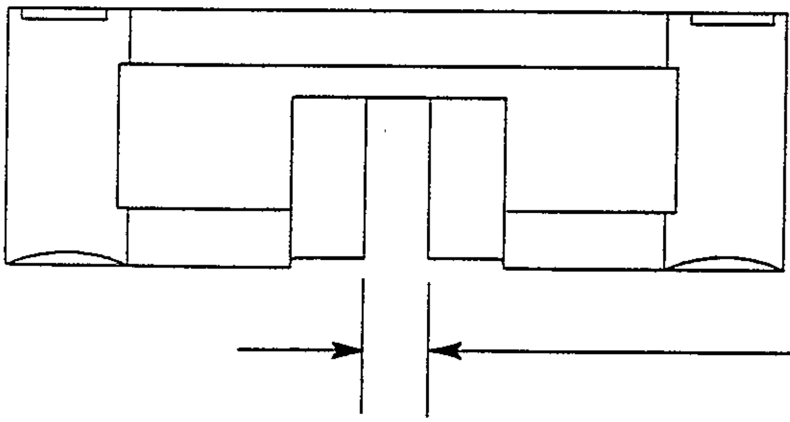

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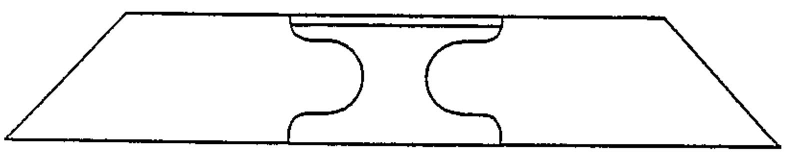
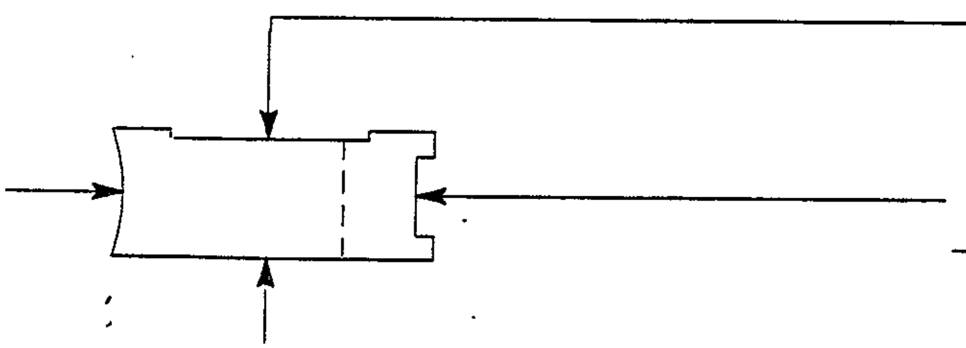


Medium to heavy scoring & pitting



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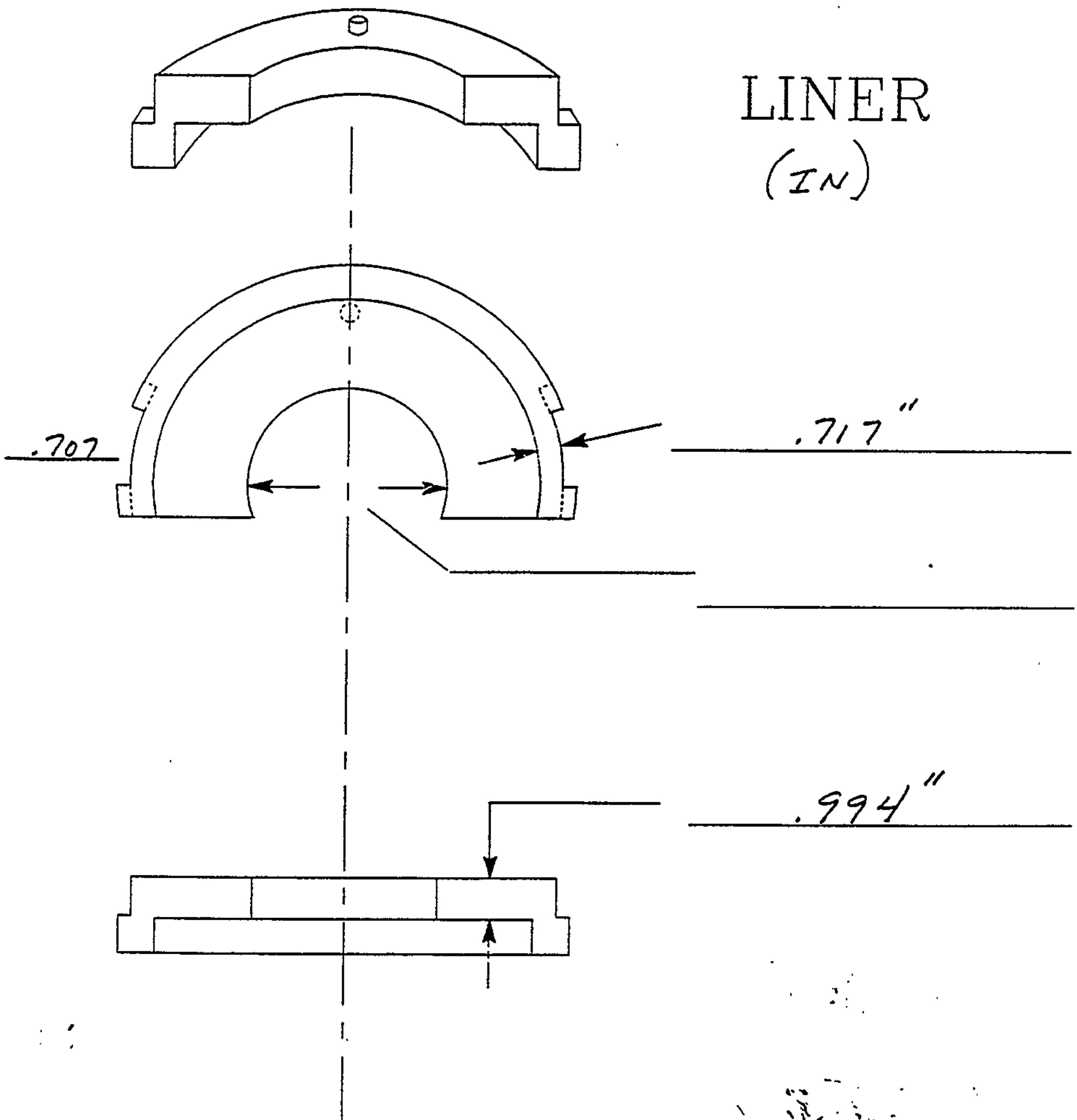

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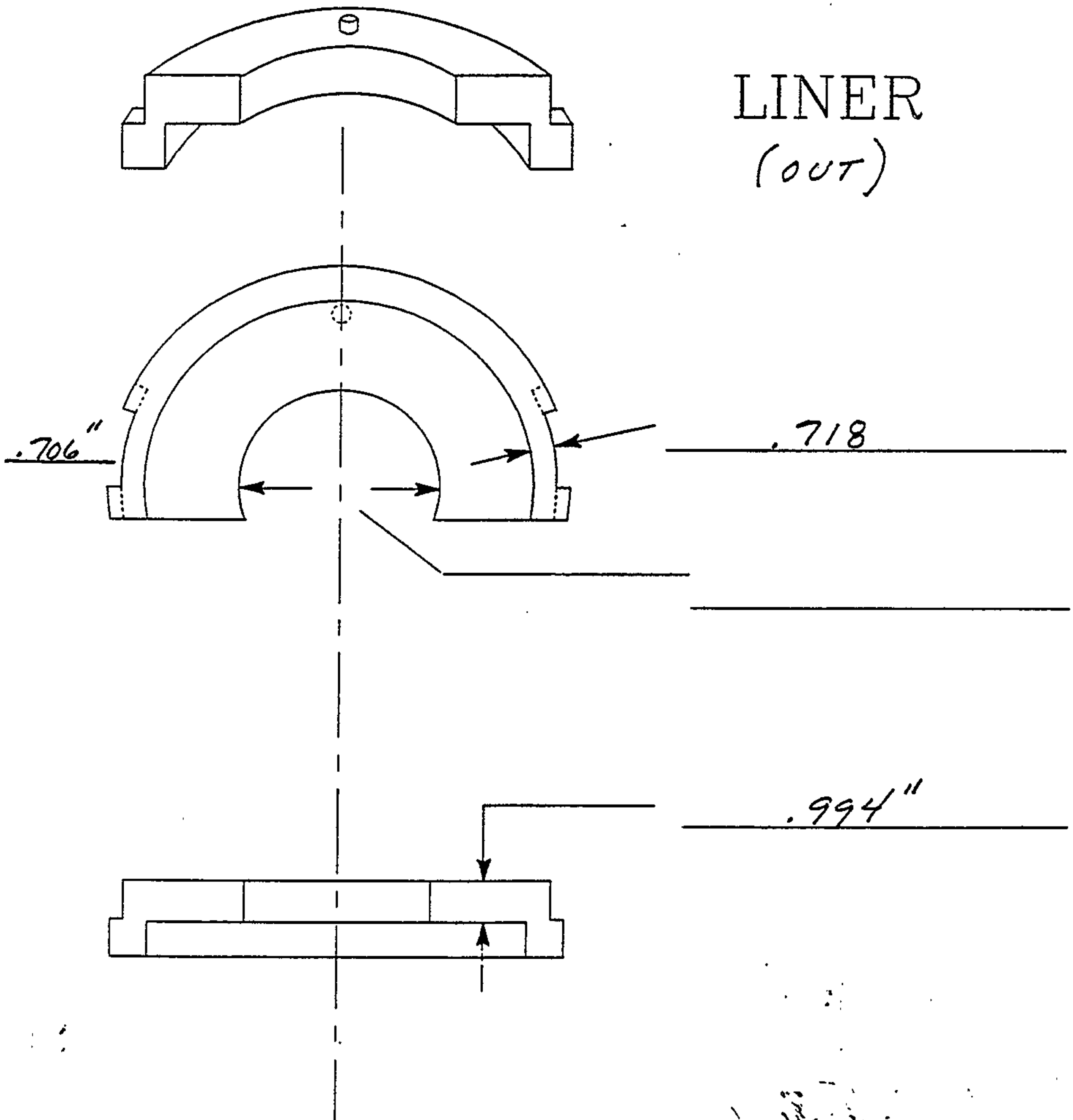


SCRAPER GATE SUPPORT

Rotated

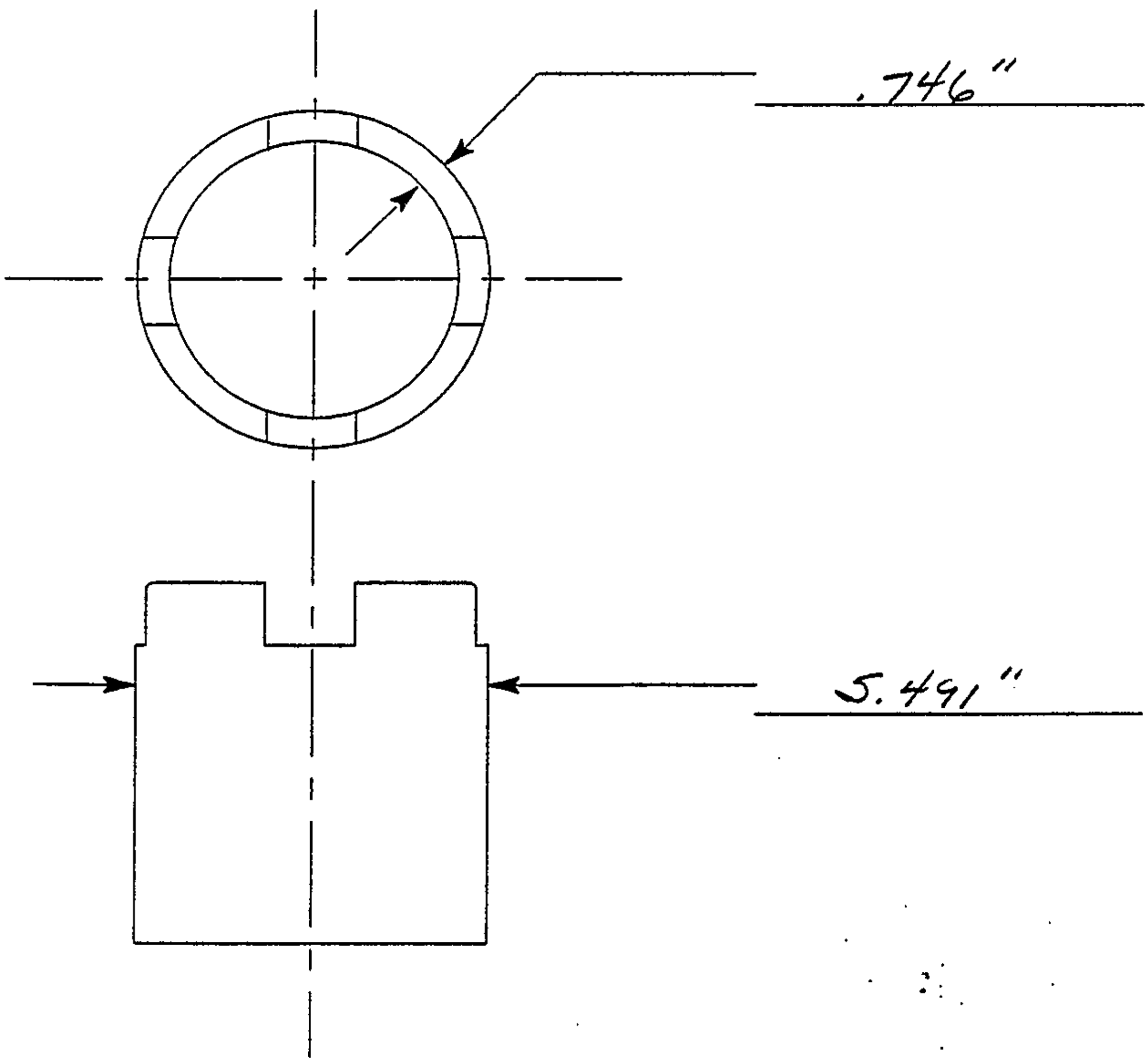
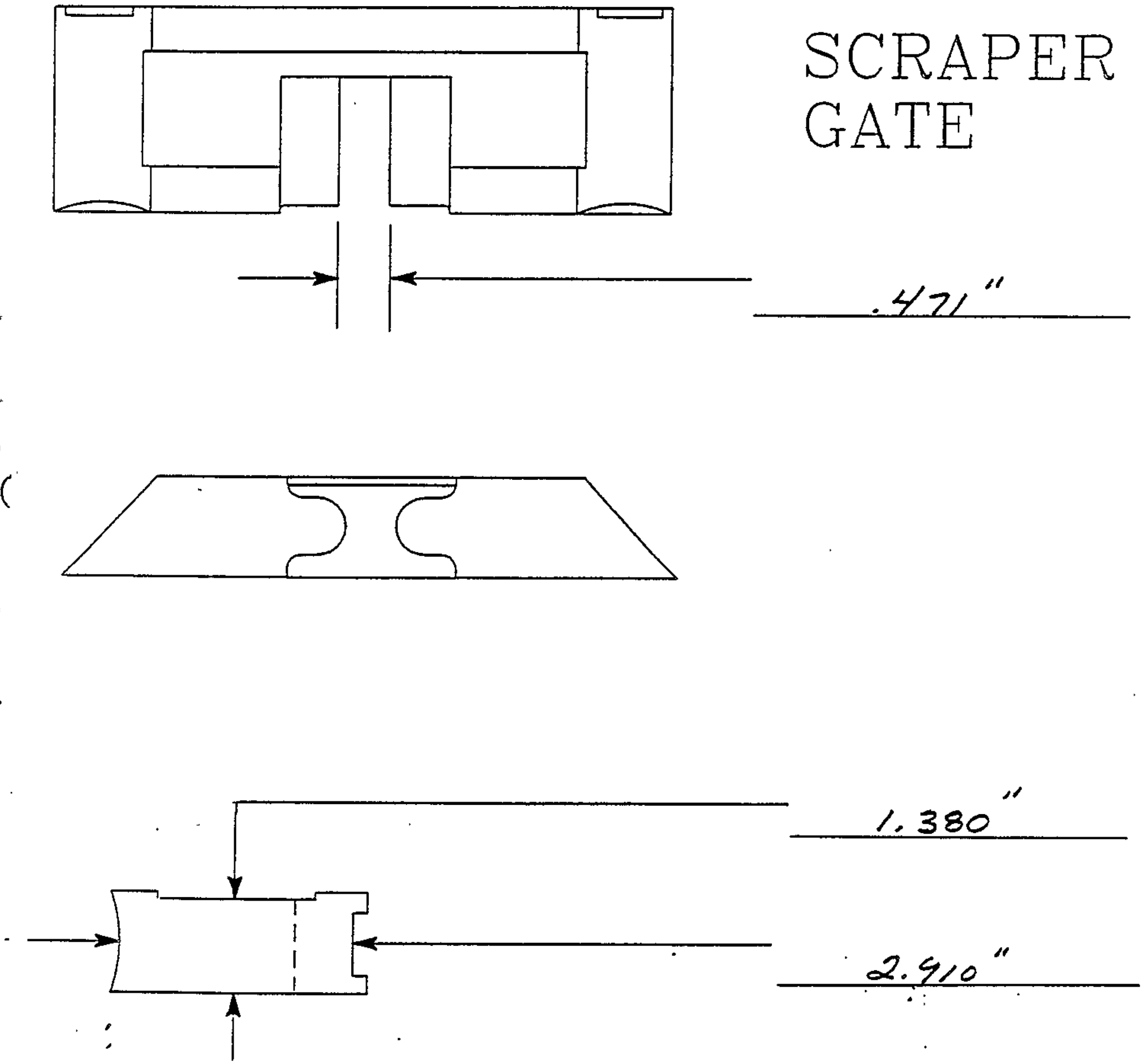


Exhibit 7

SCRAPER GATE



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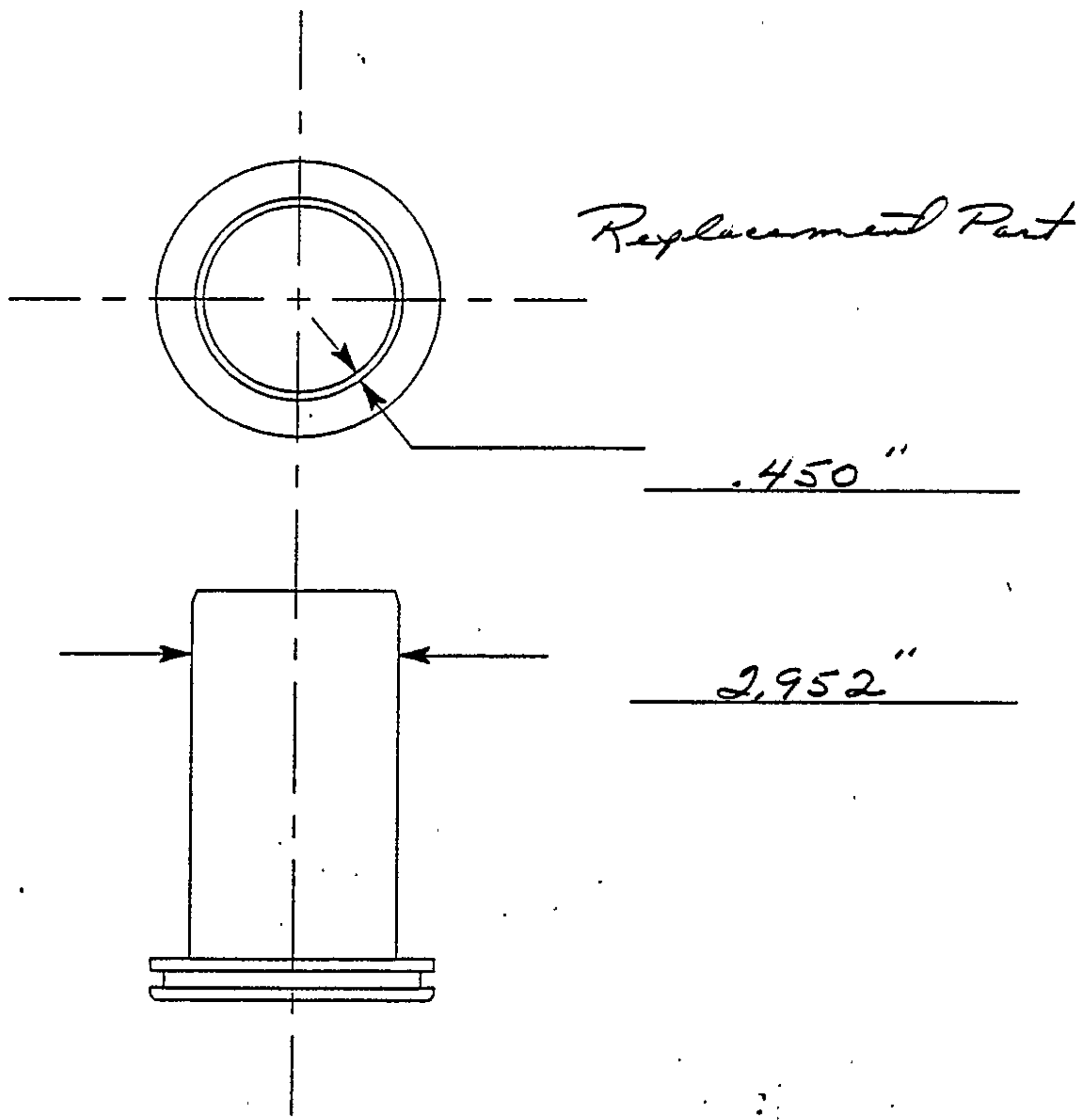

Exhibit 8

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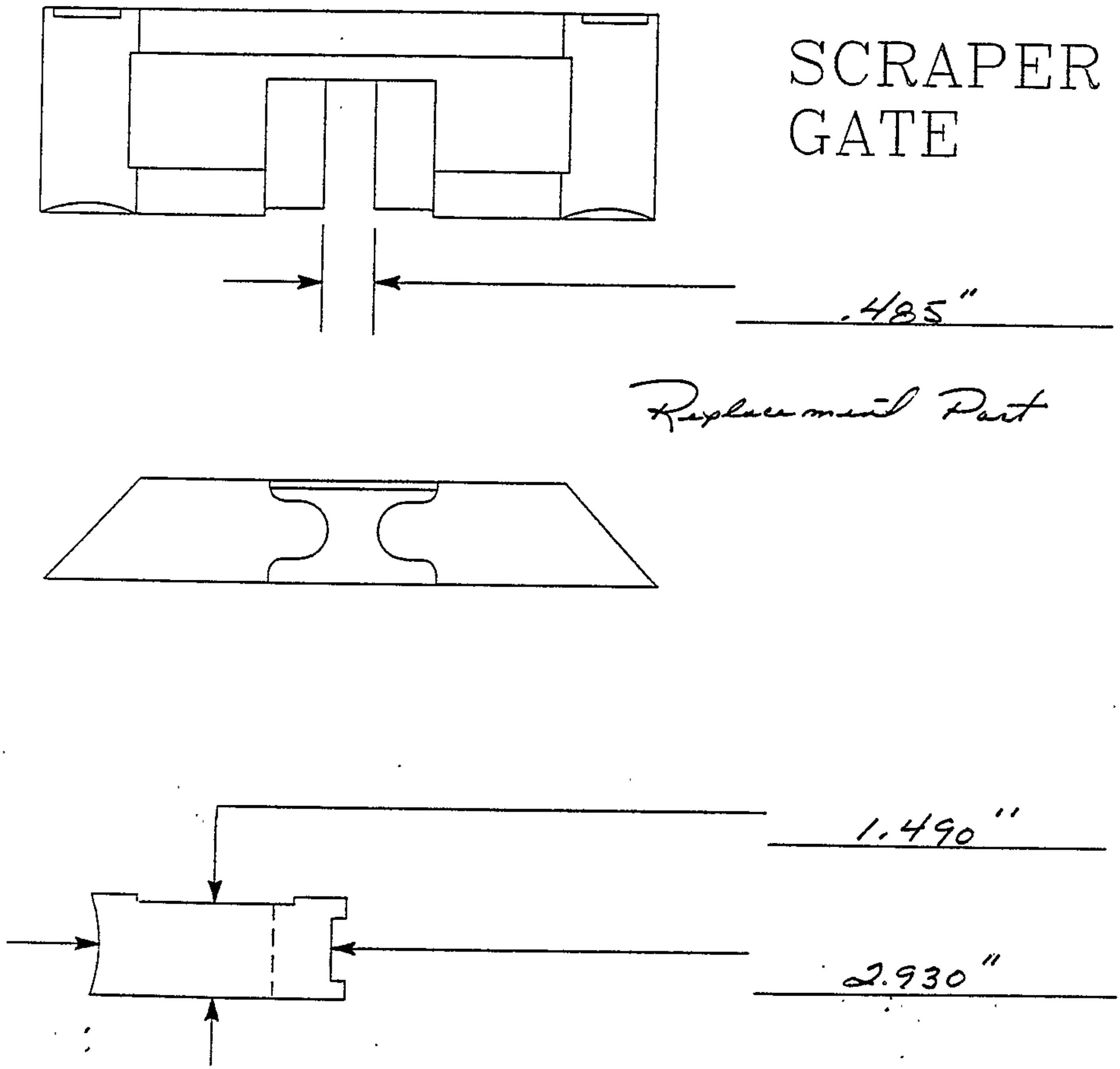

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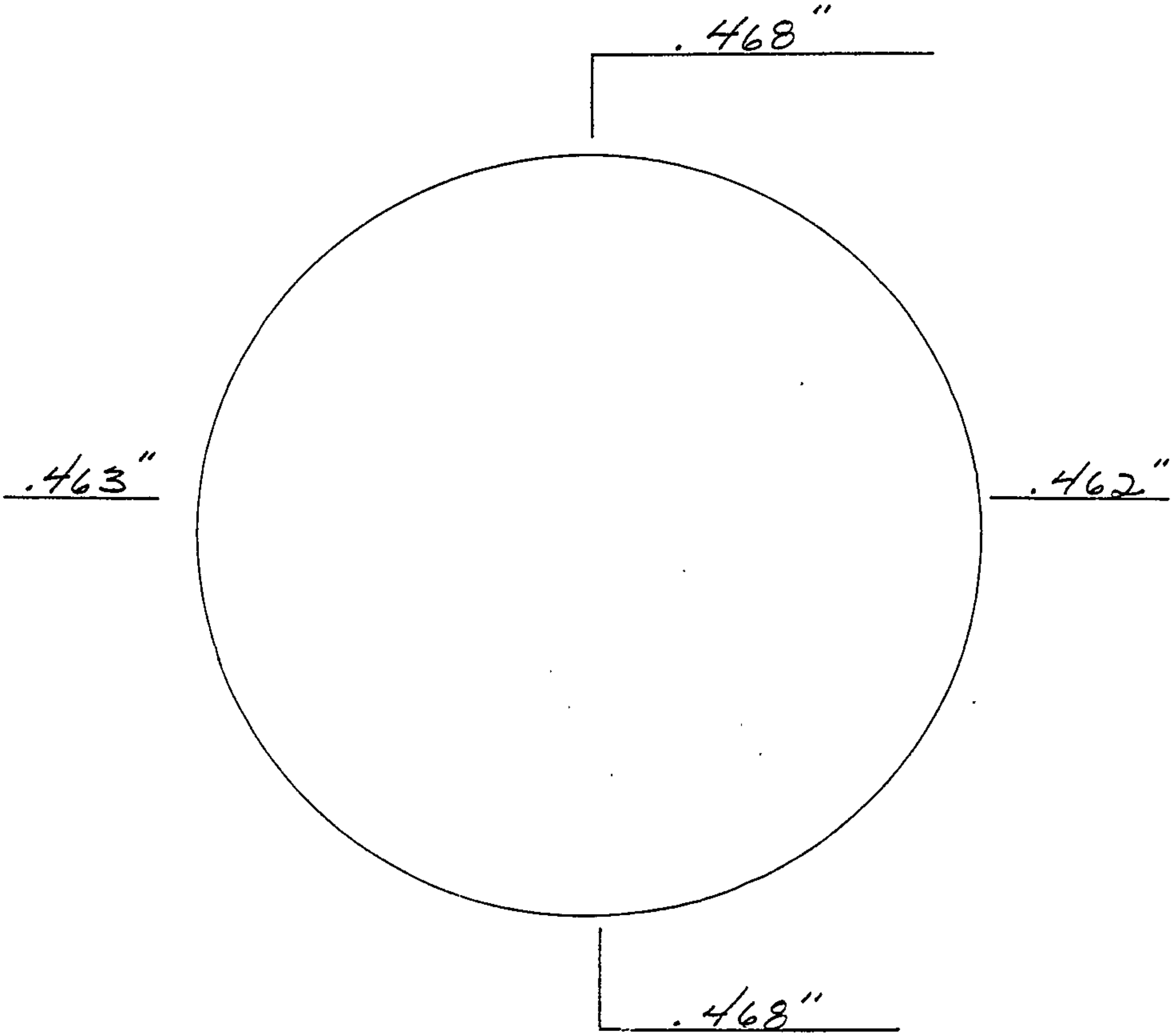

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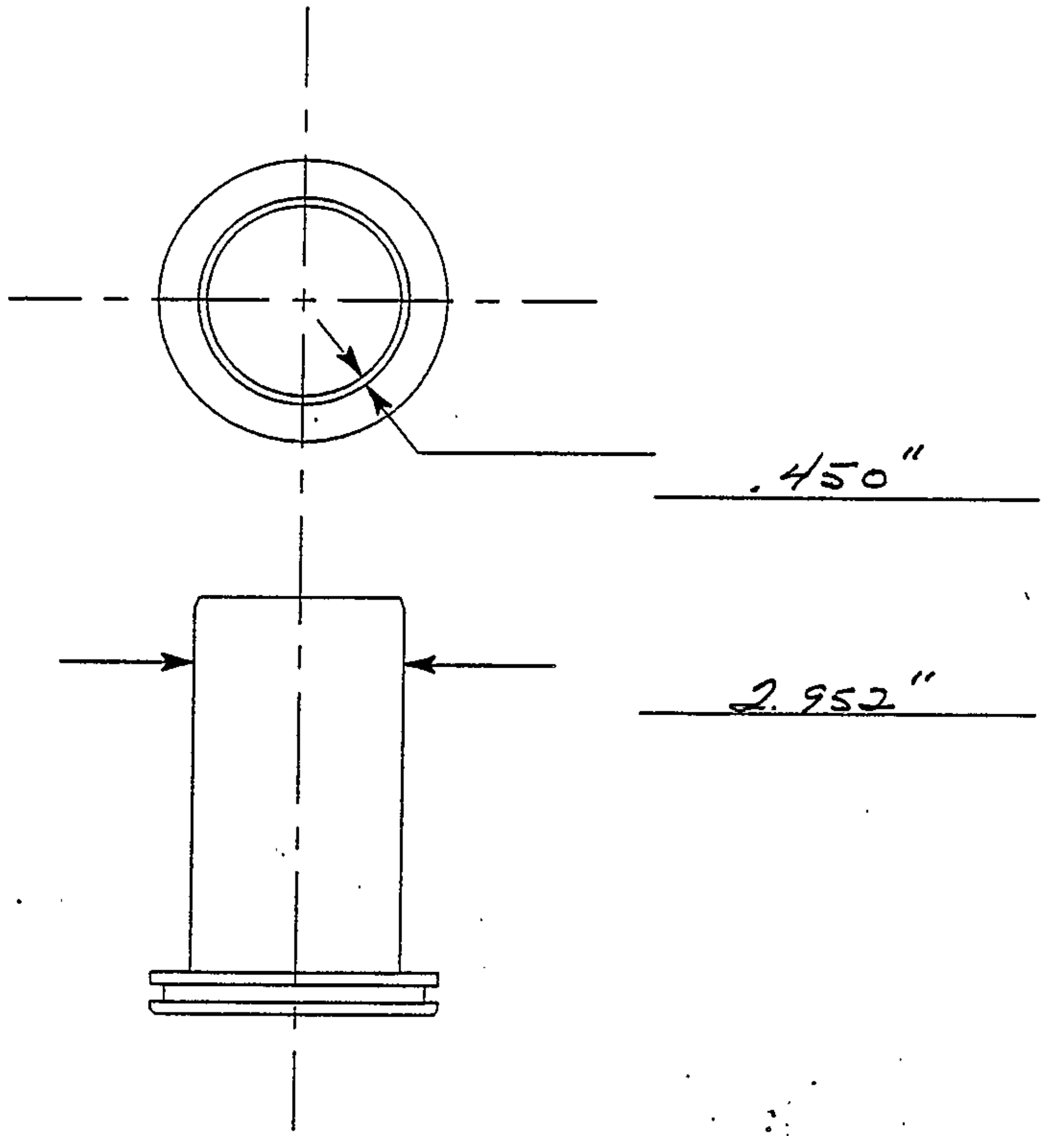

Exhibit 9

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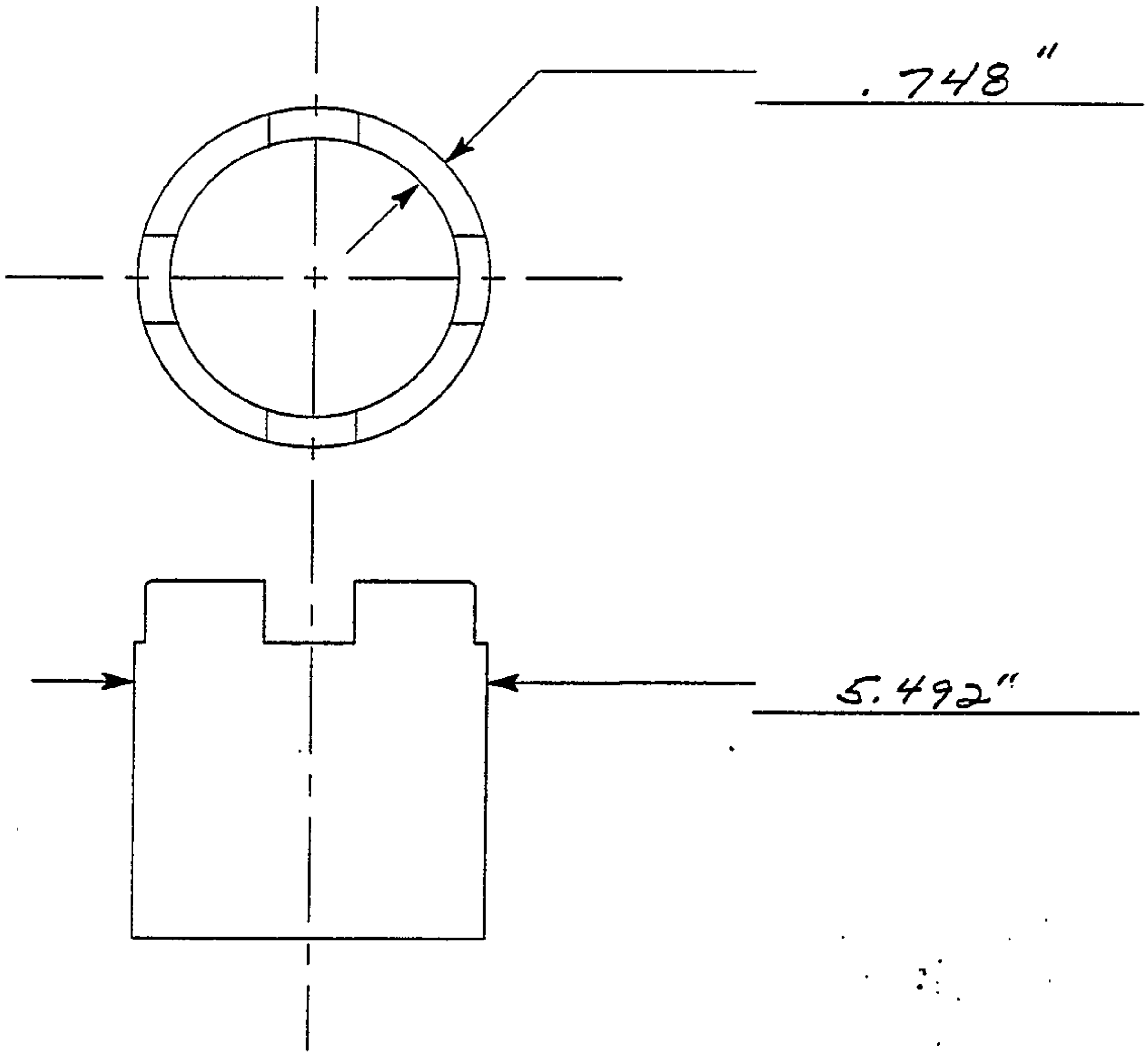

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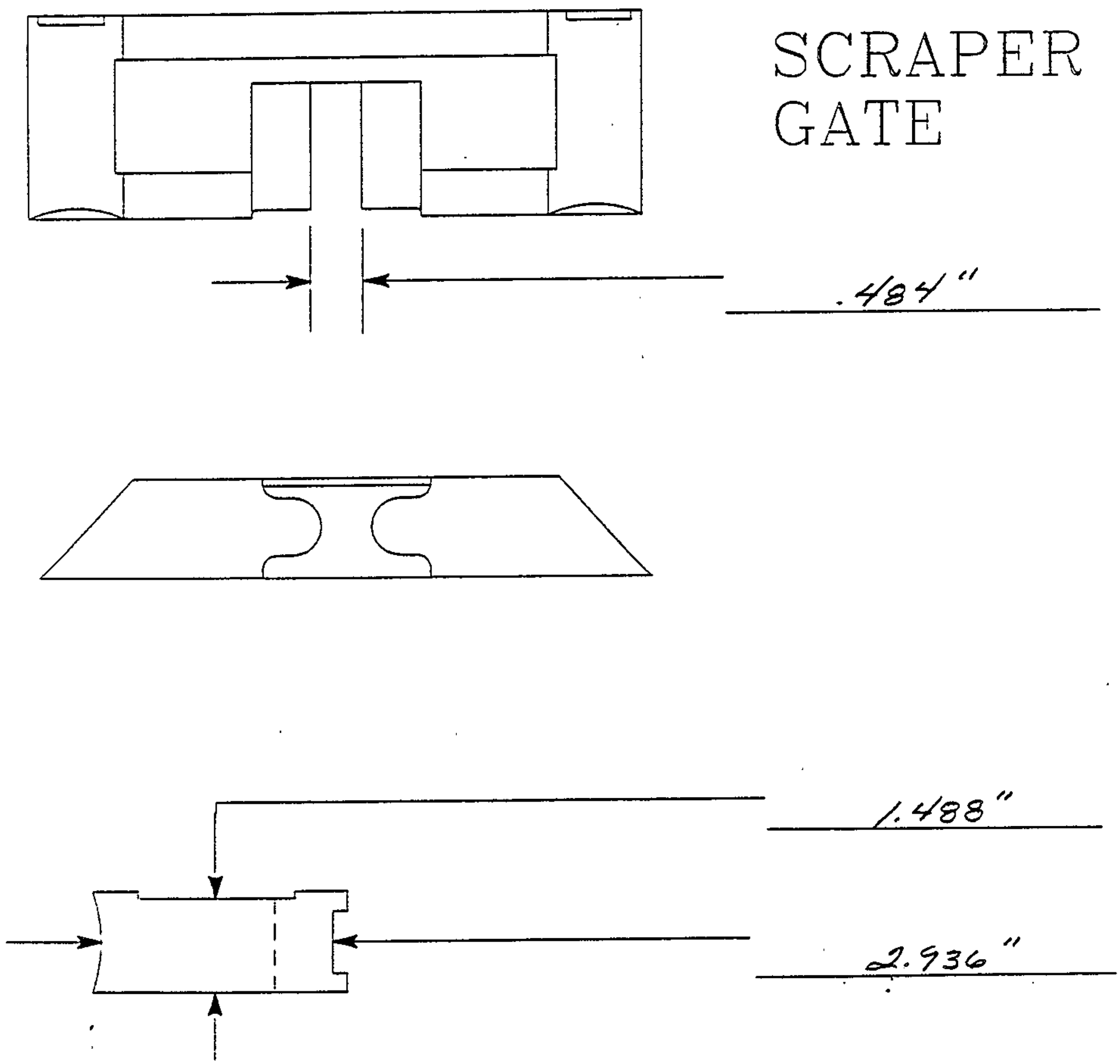

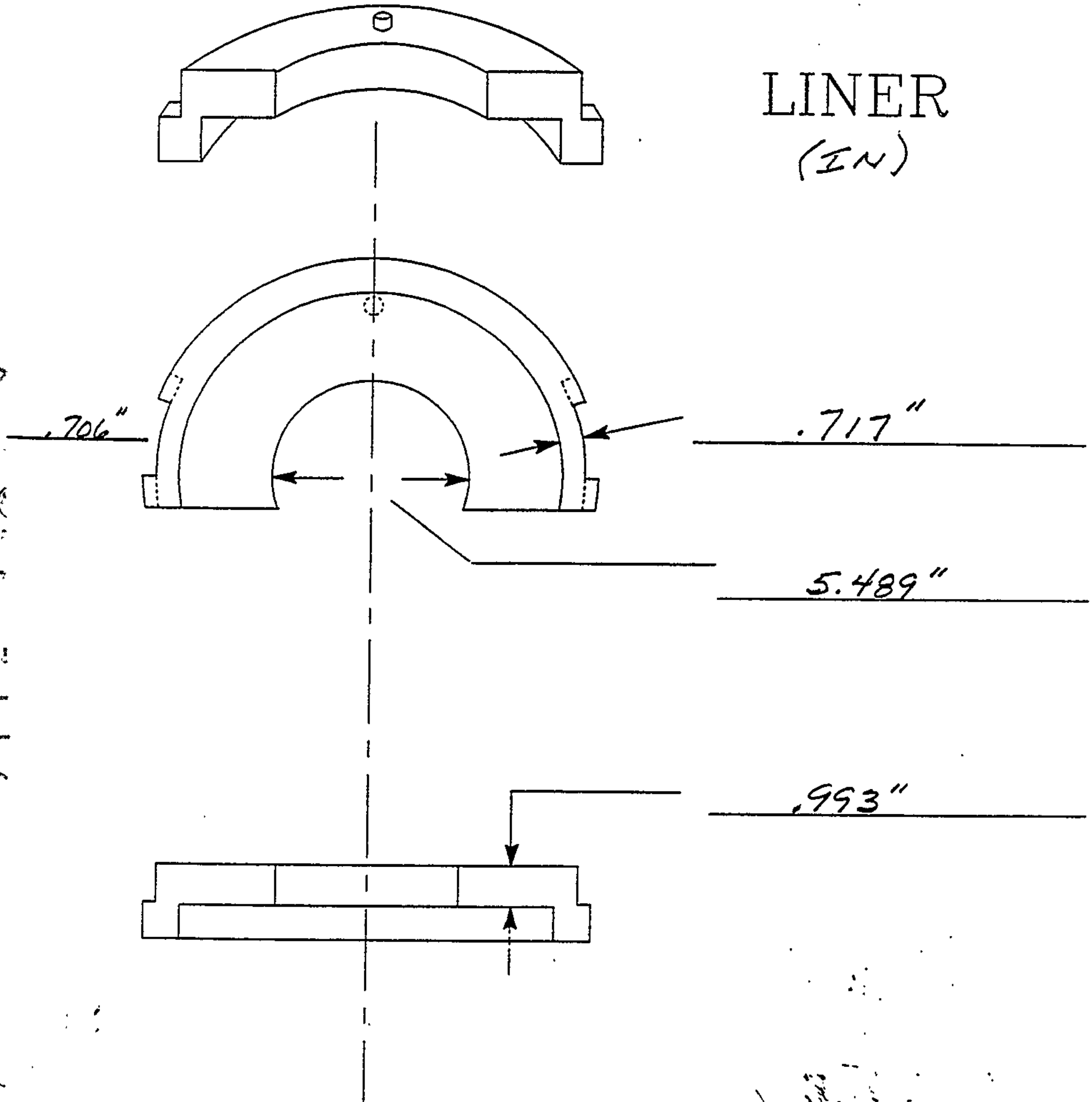
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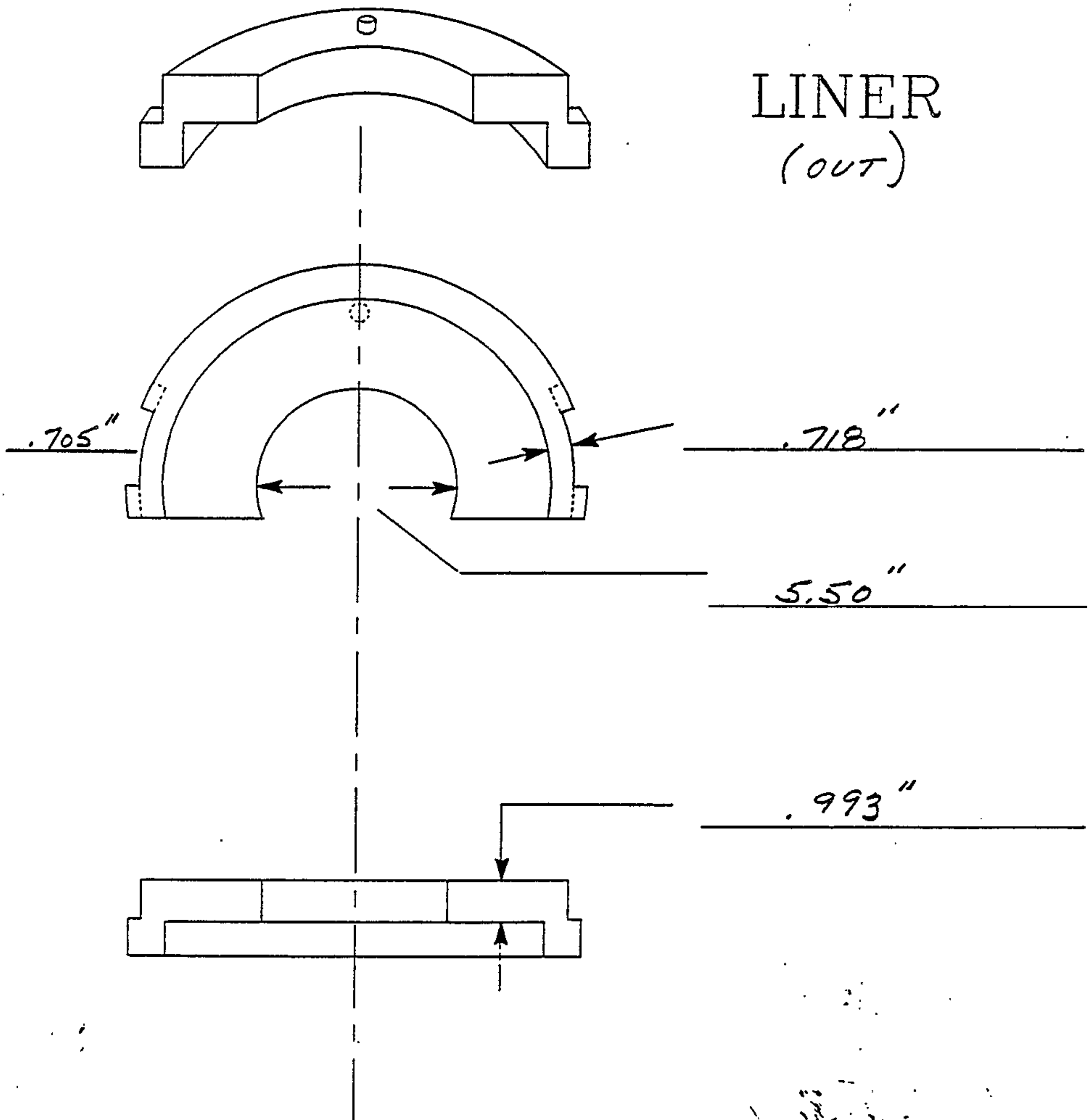

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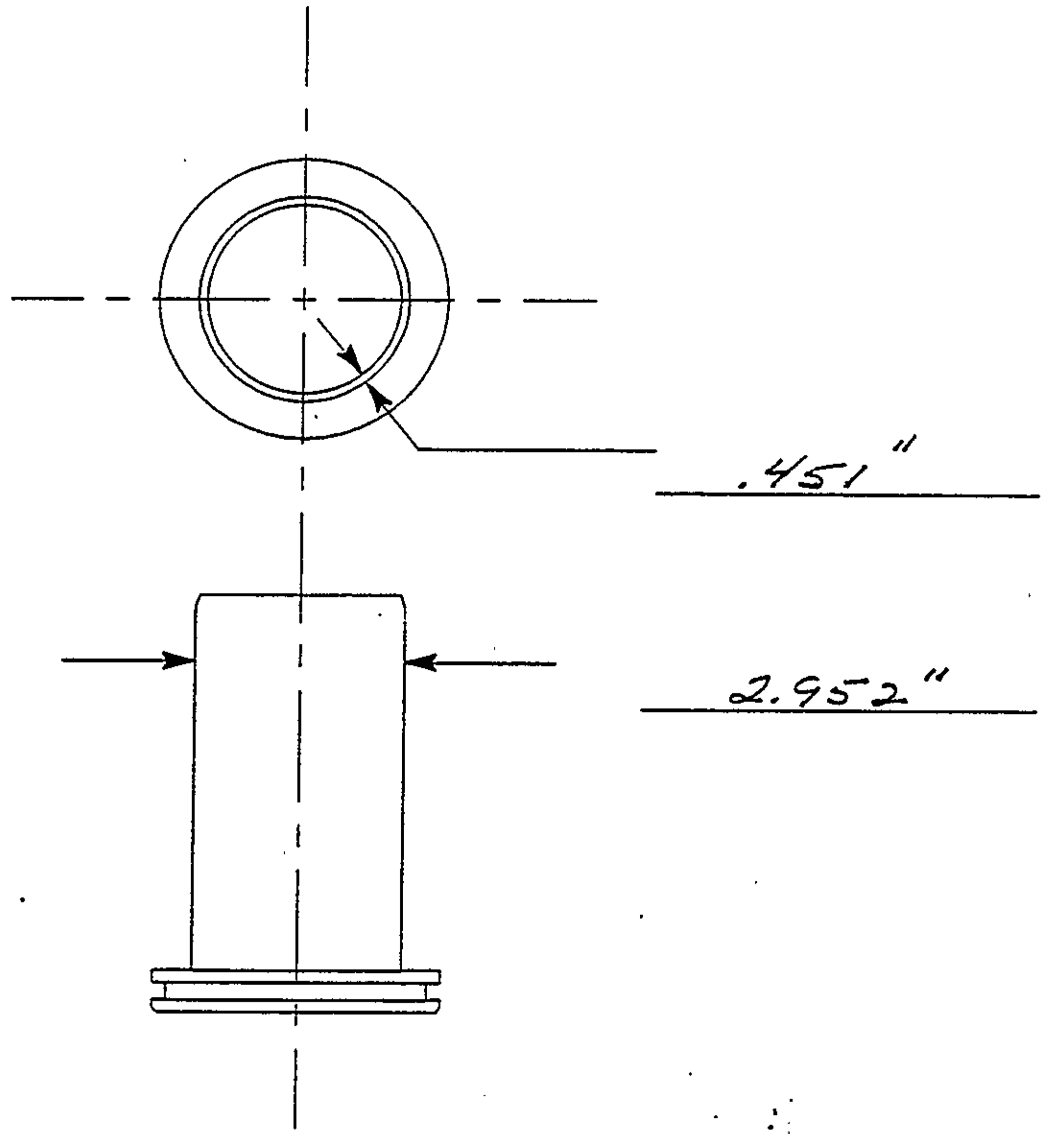

Exhibit 10

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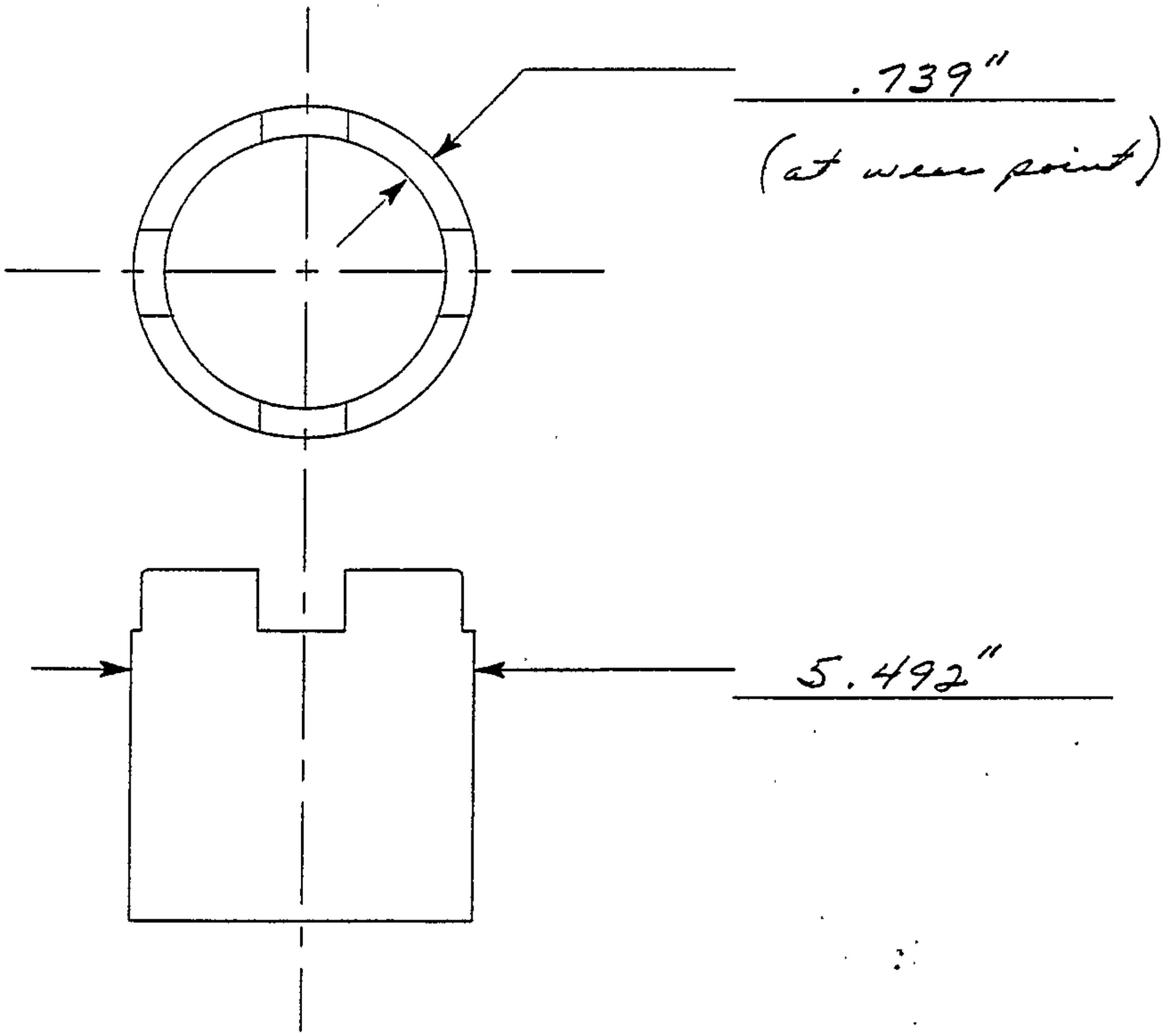

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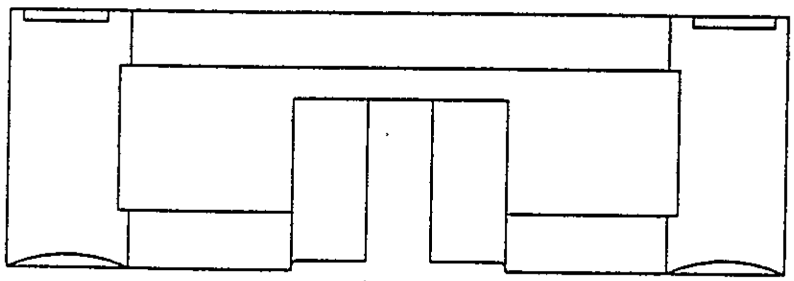

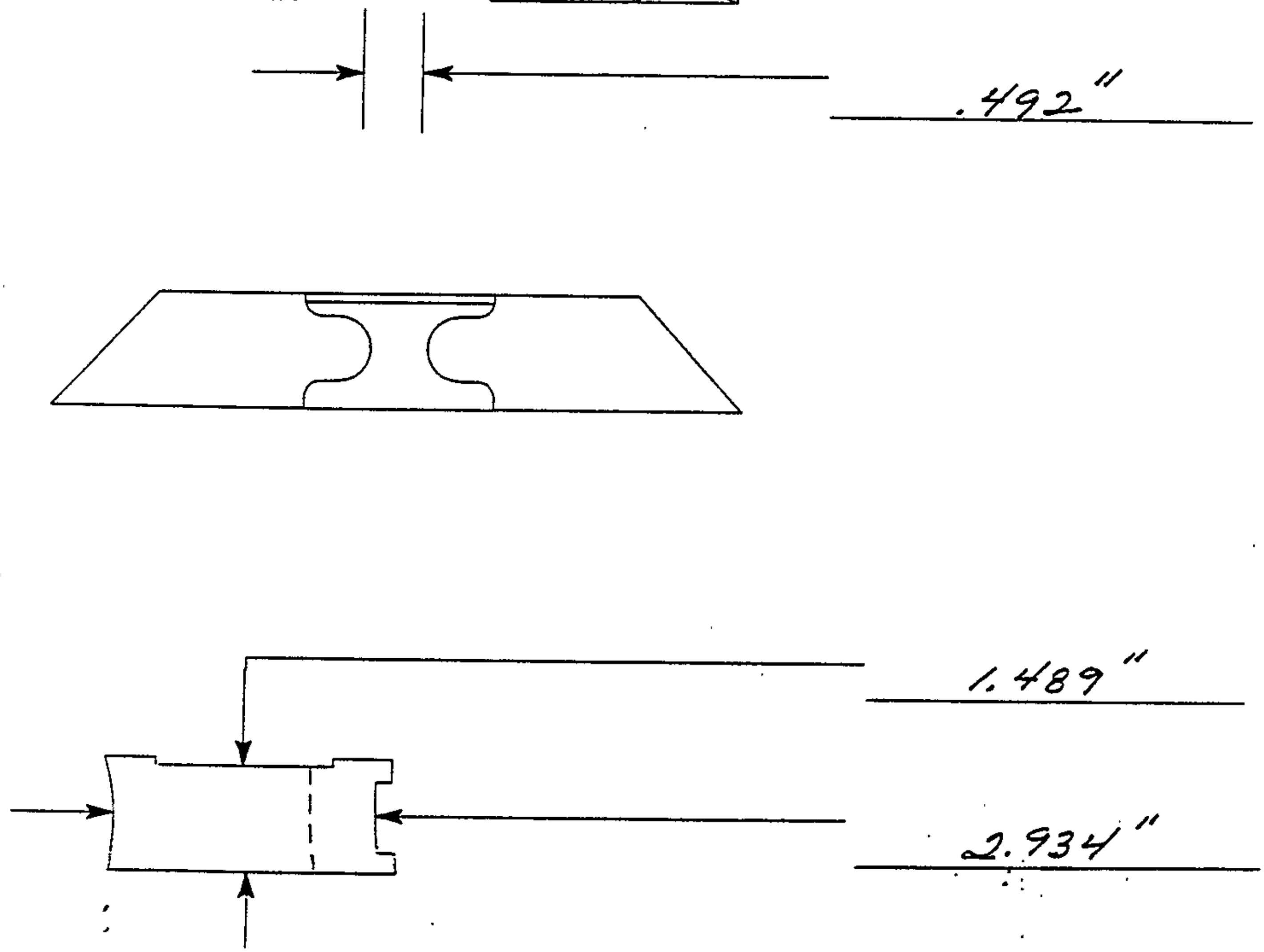

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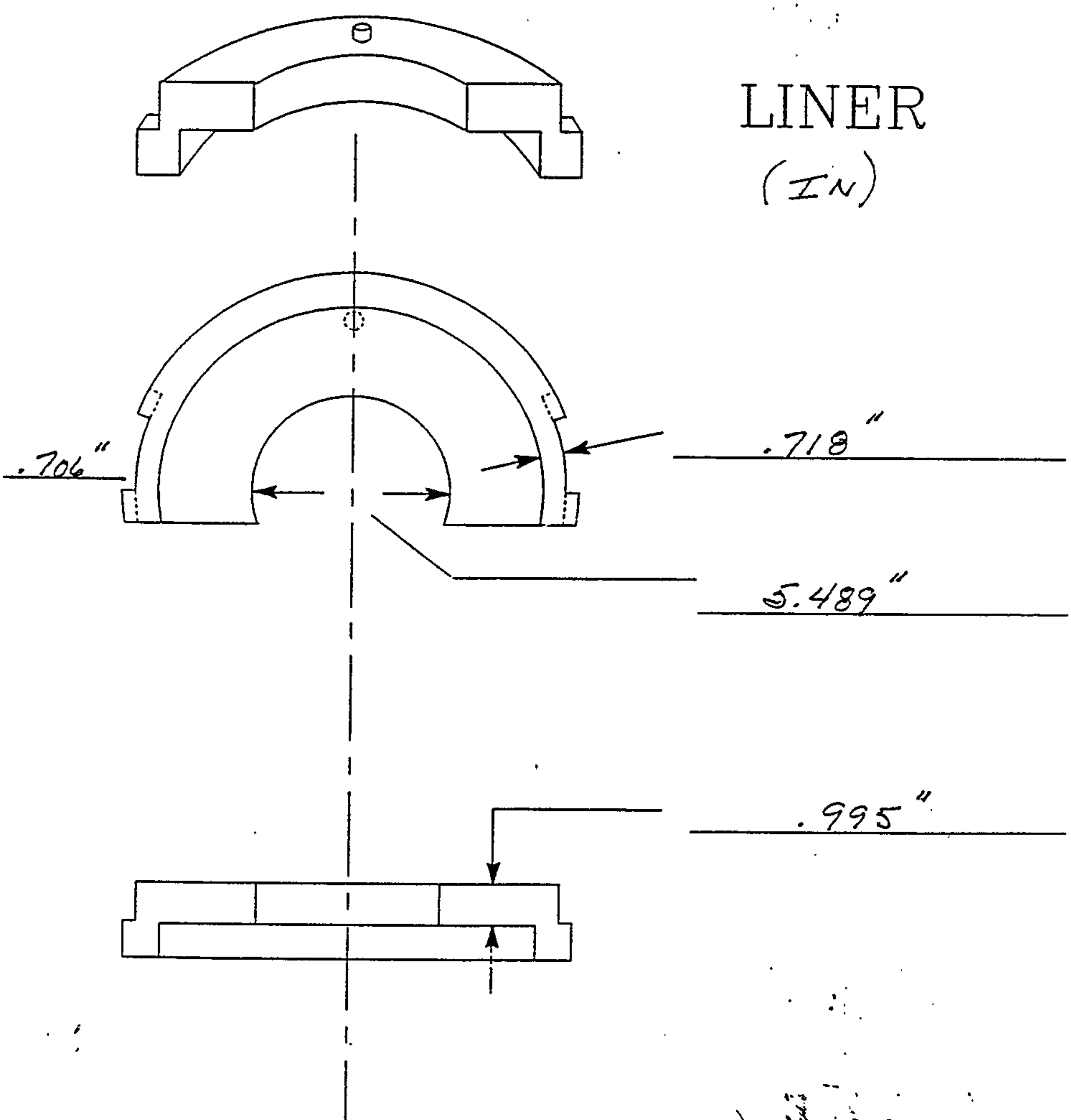

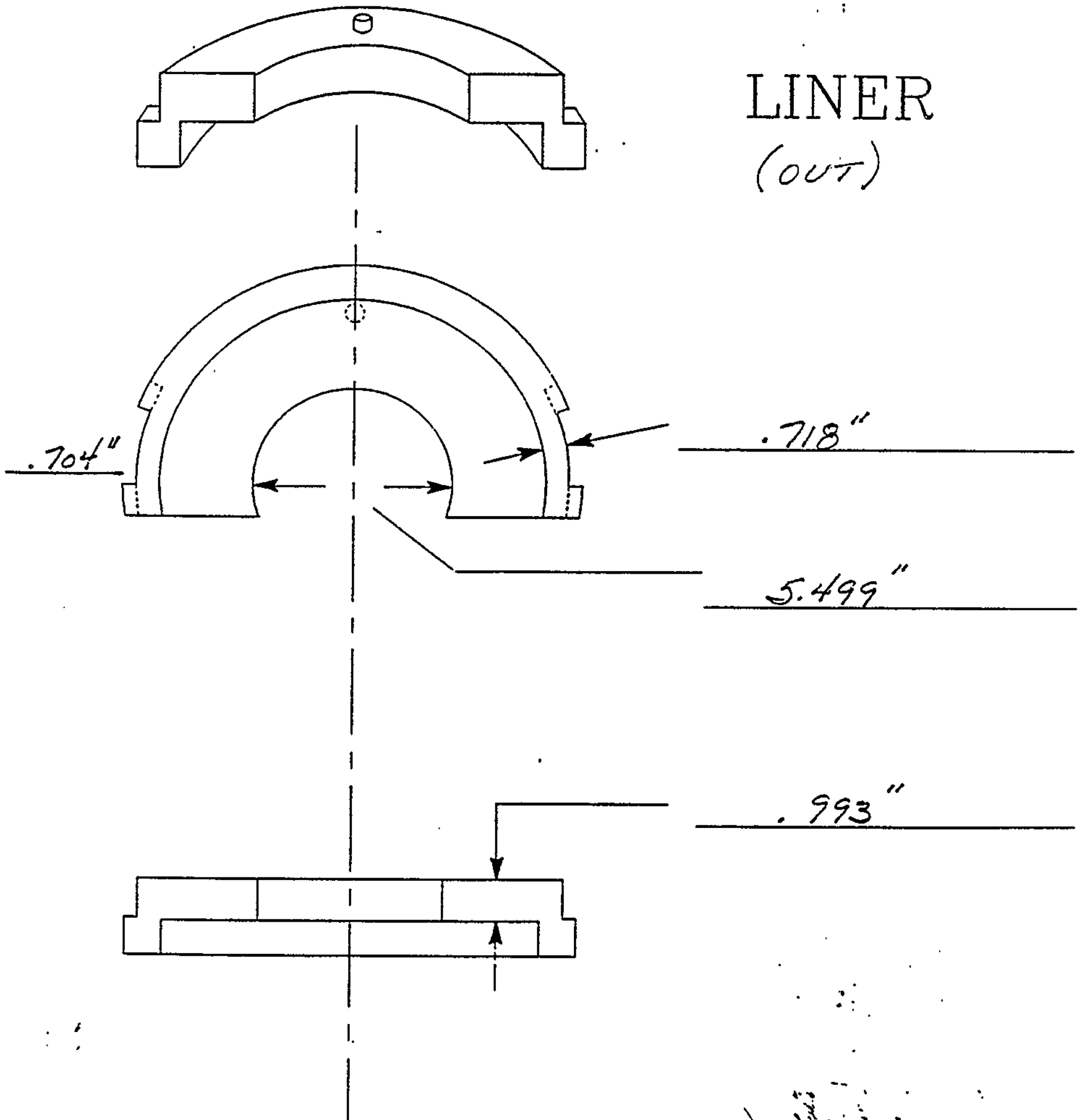
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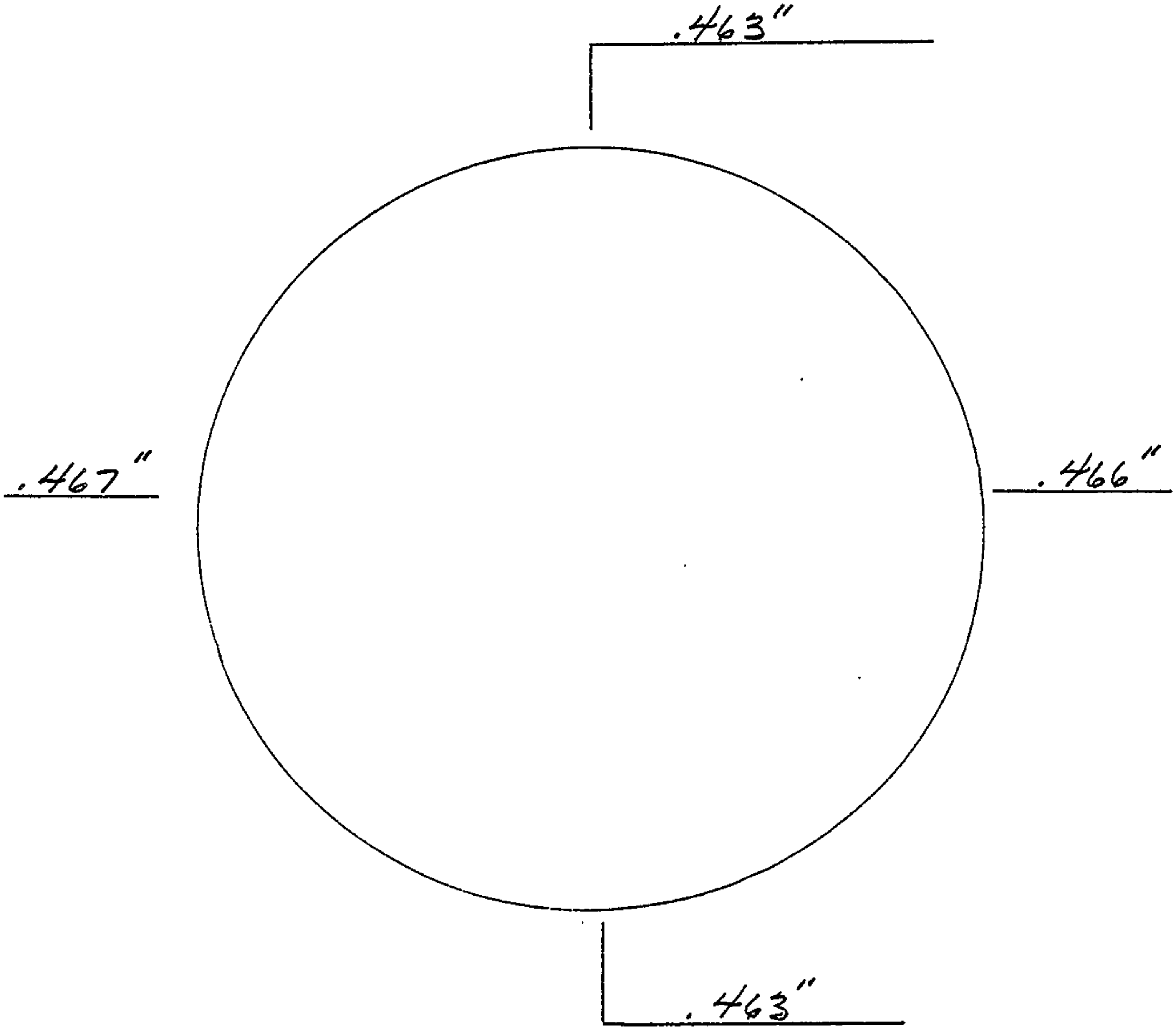
IMPELLER



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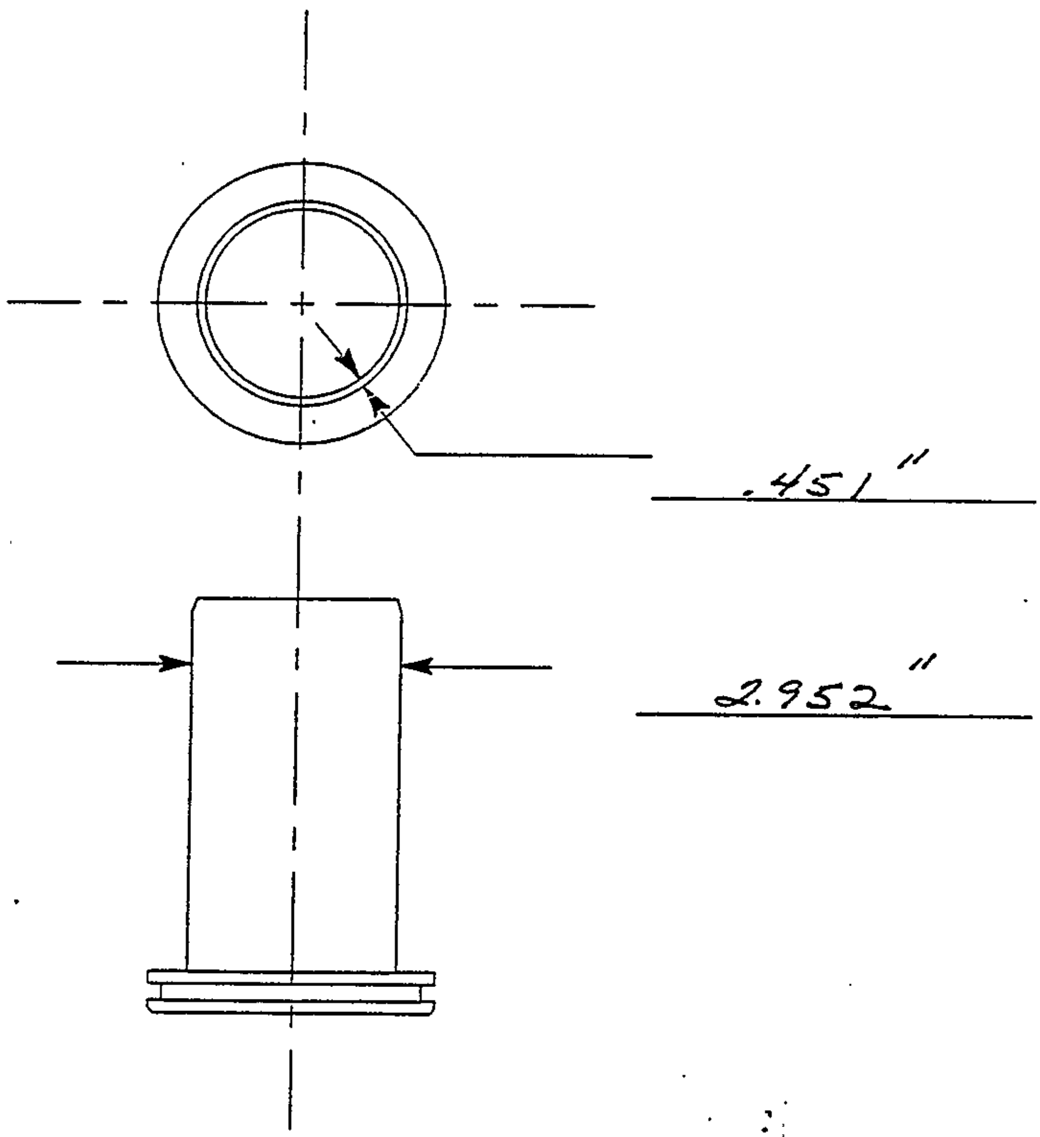

Exhibit 11

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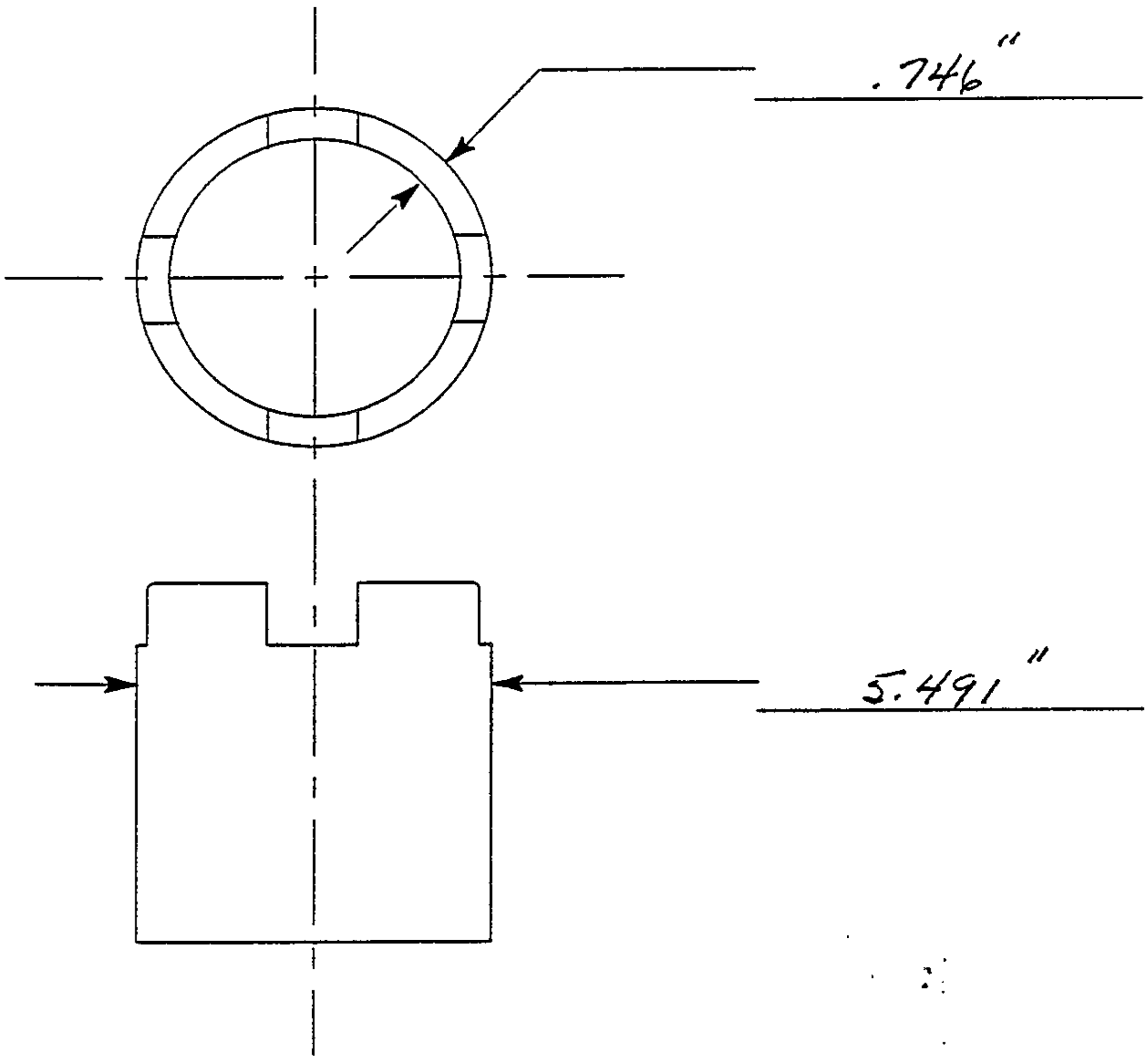

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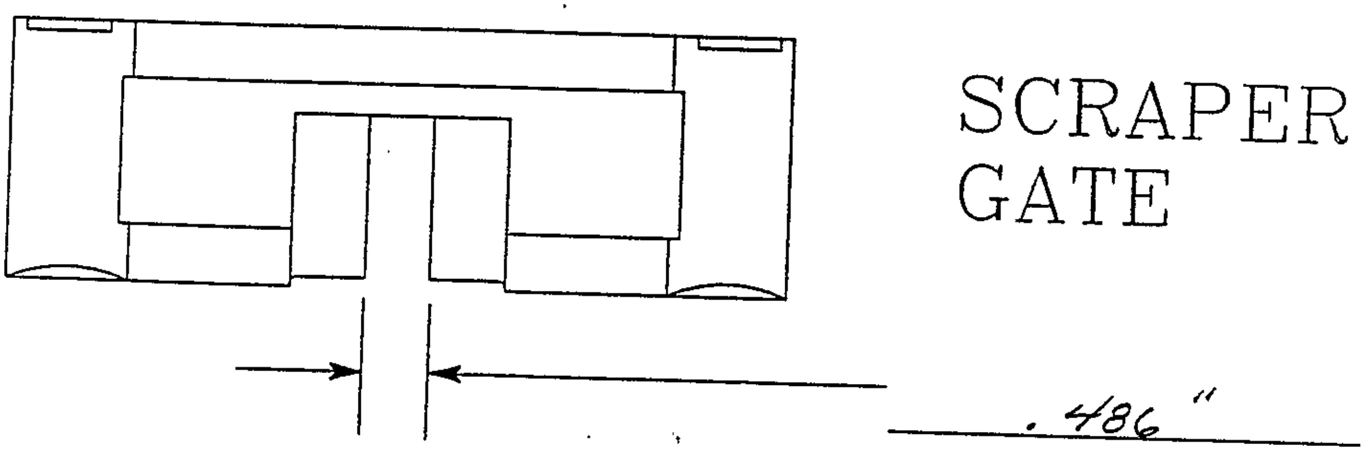

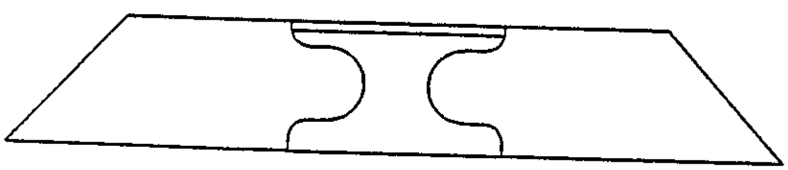

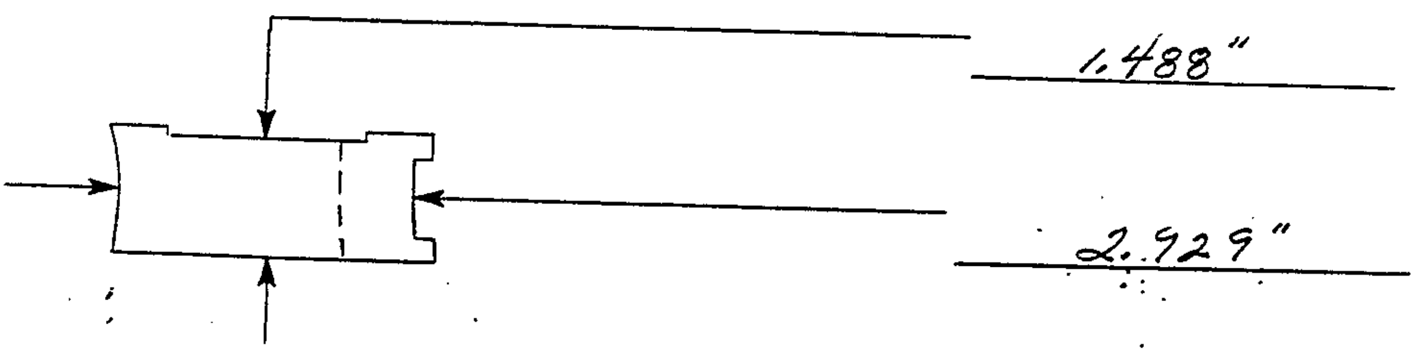

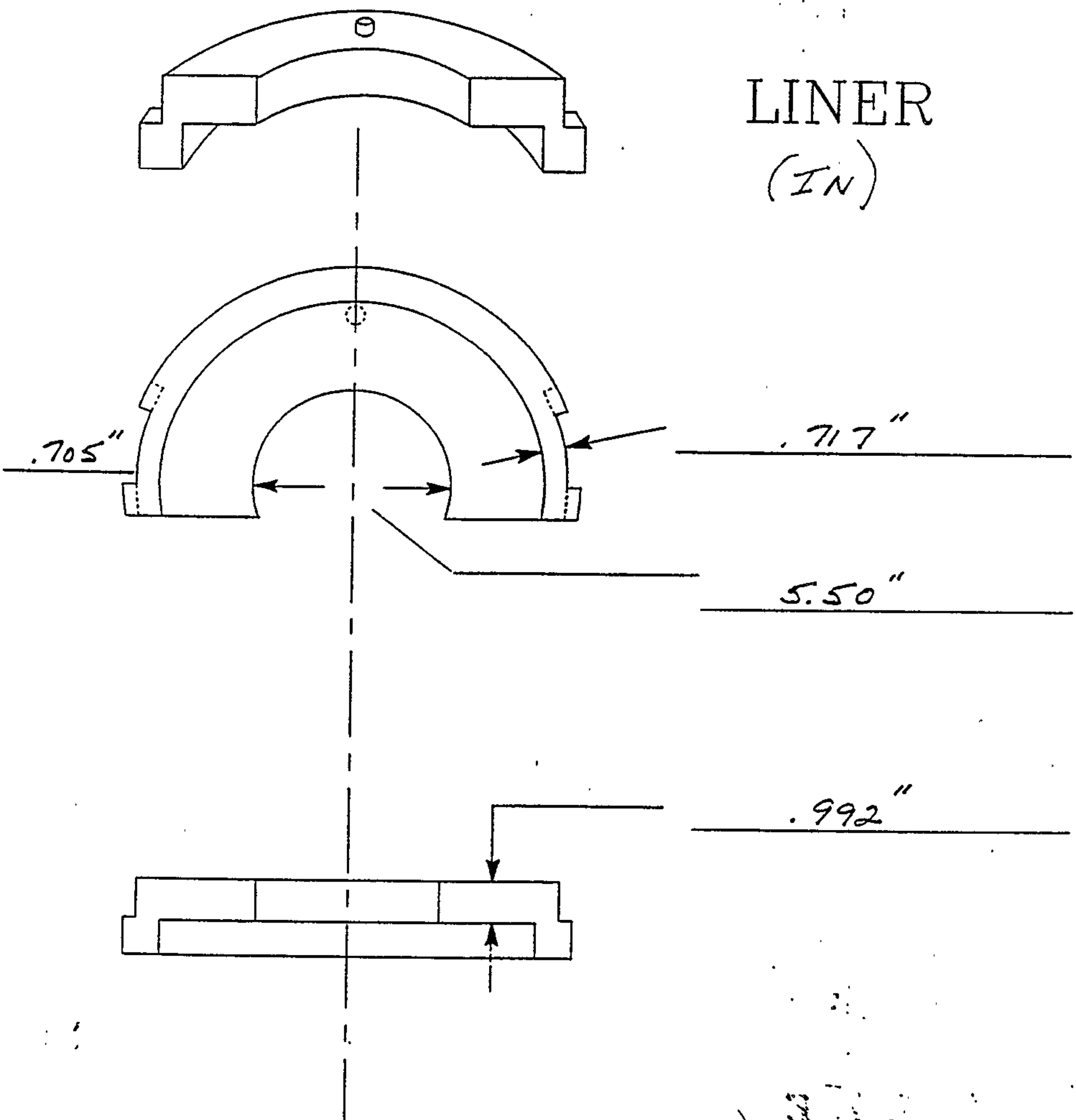
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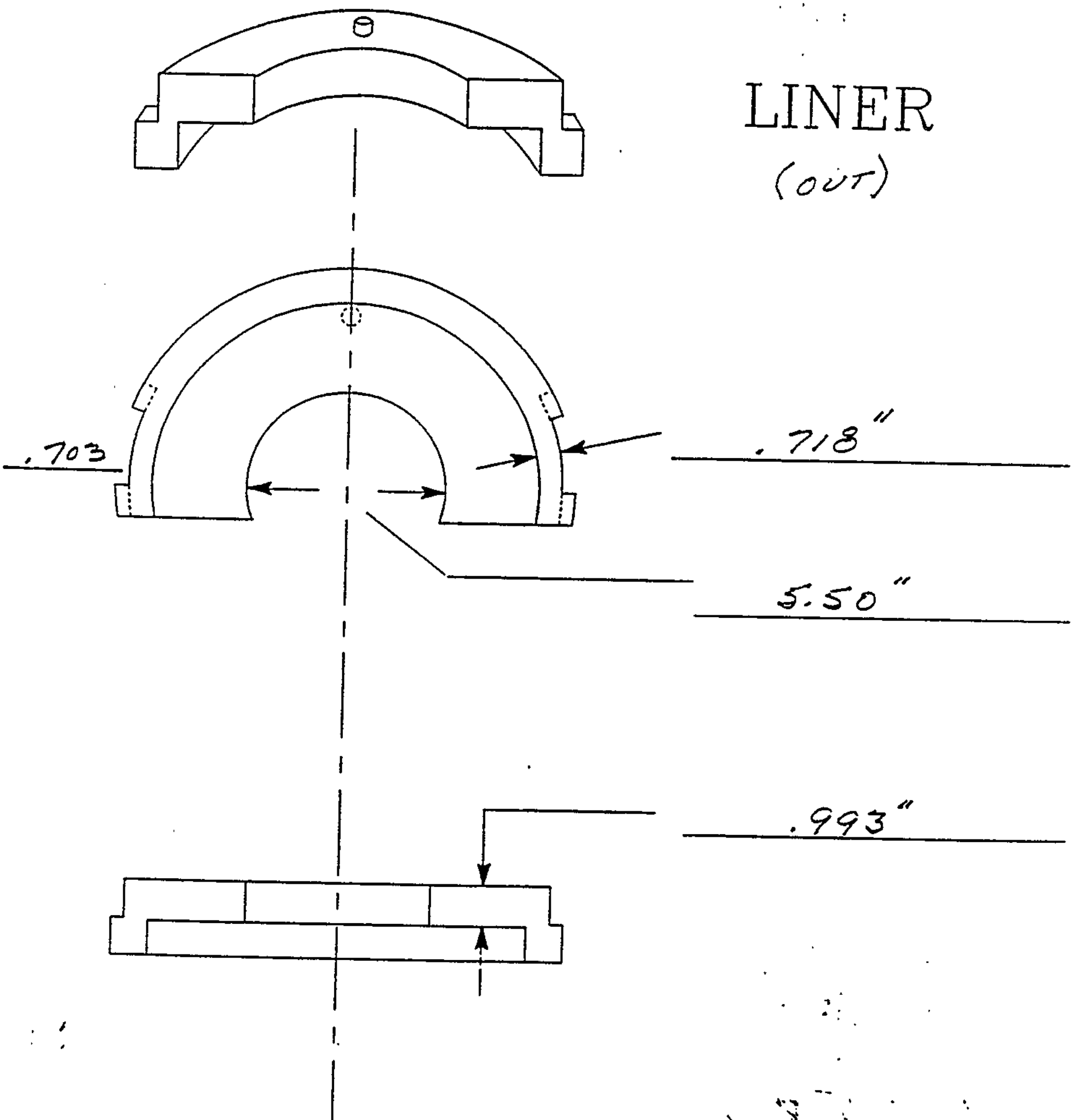
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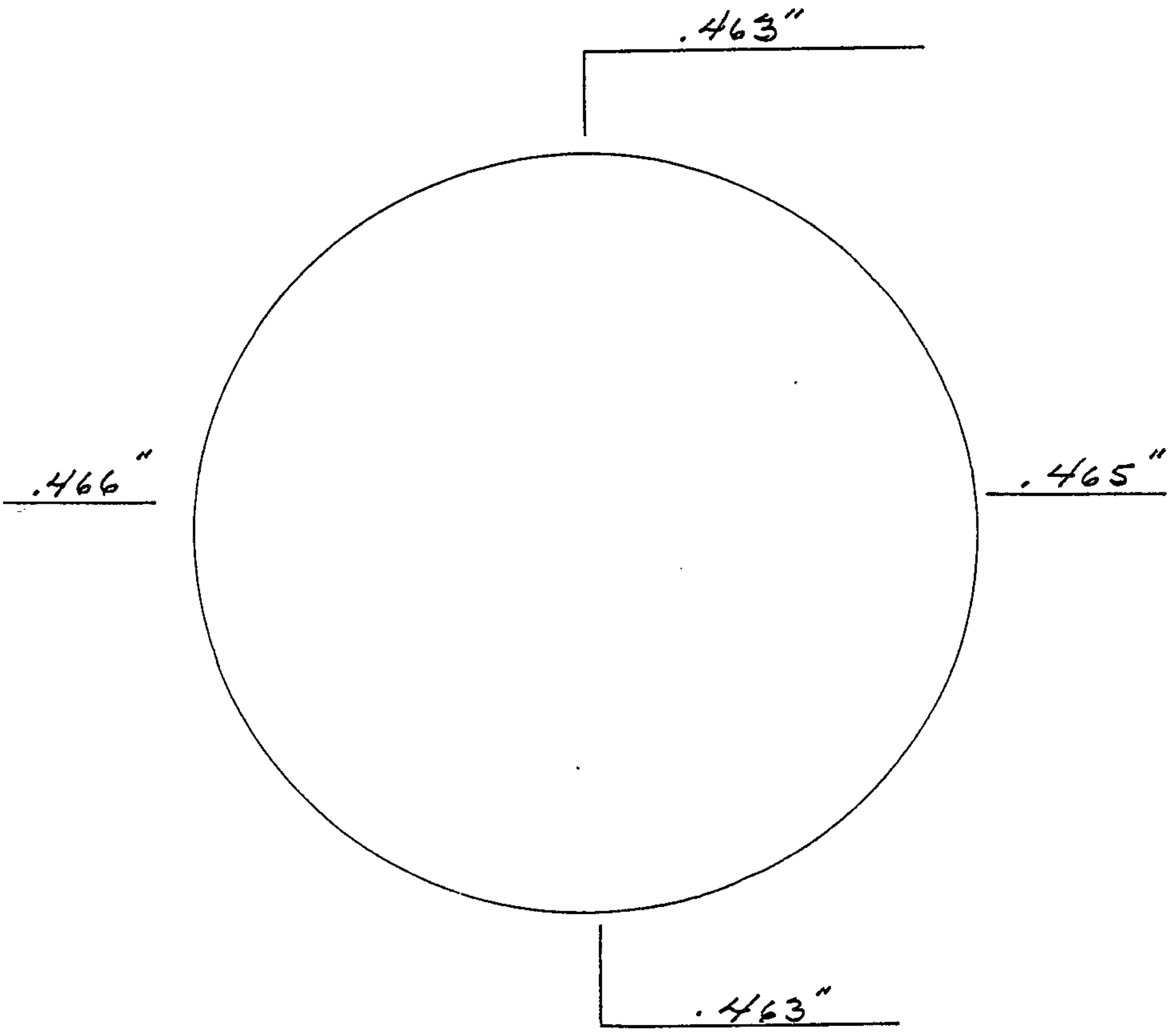

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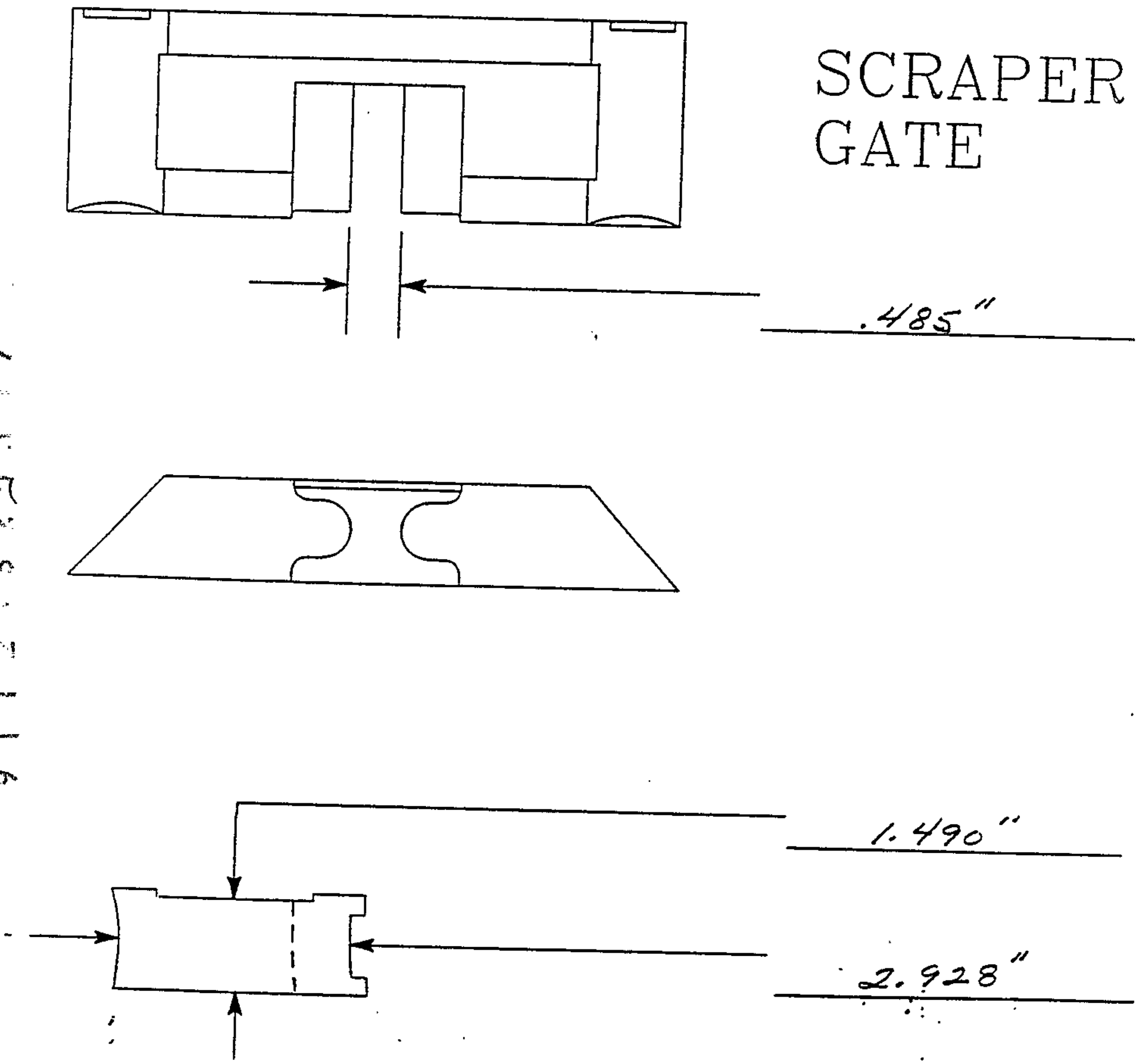

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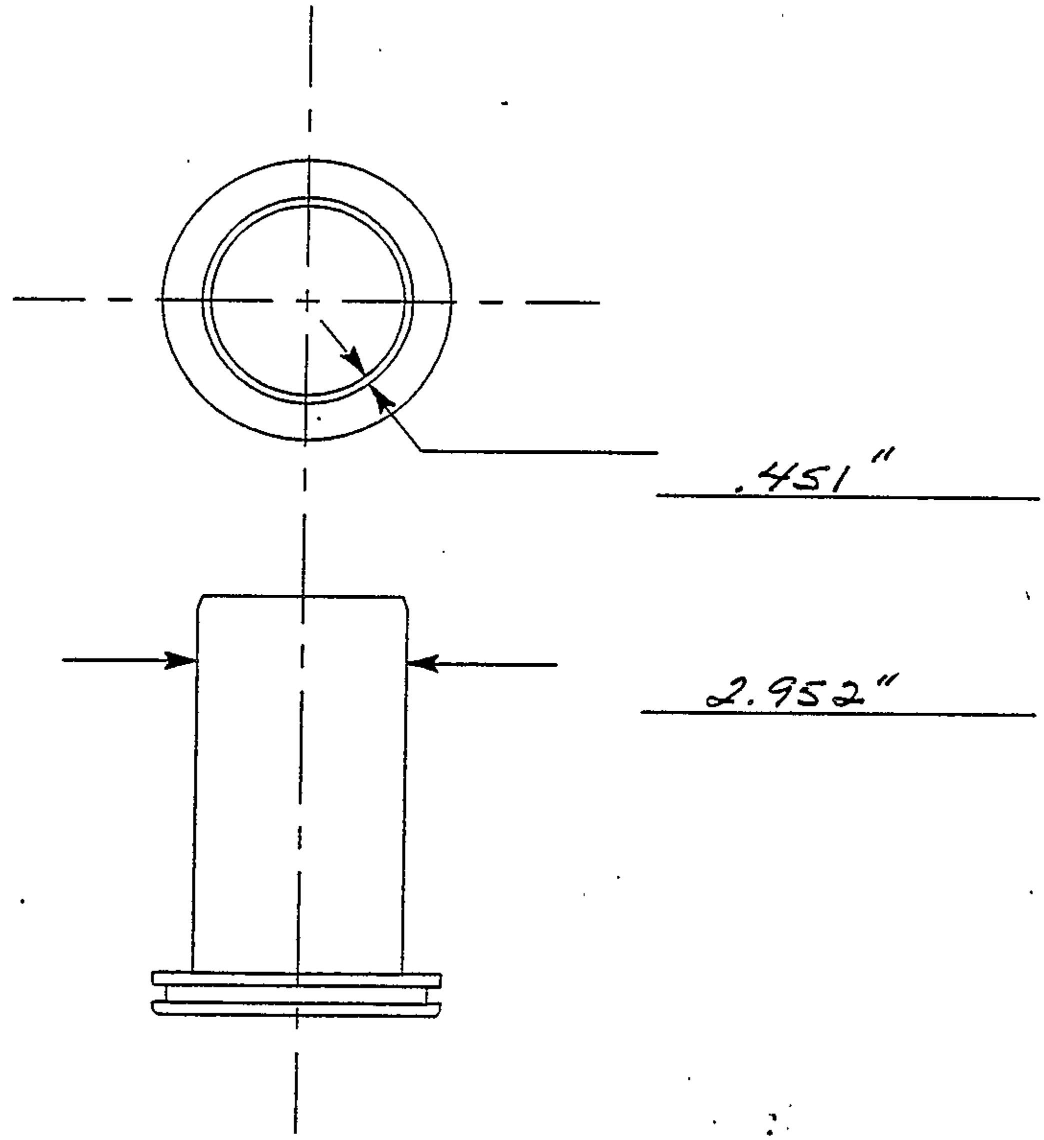

Exhibit 13

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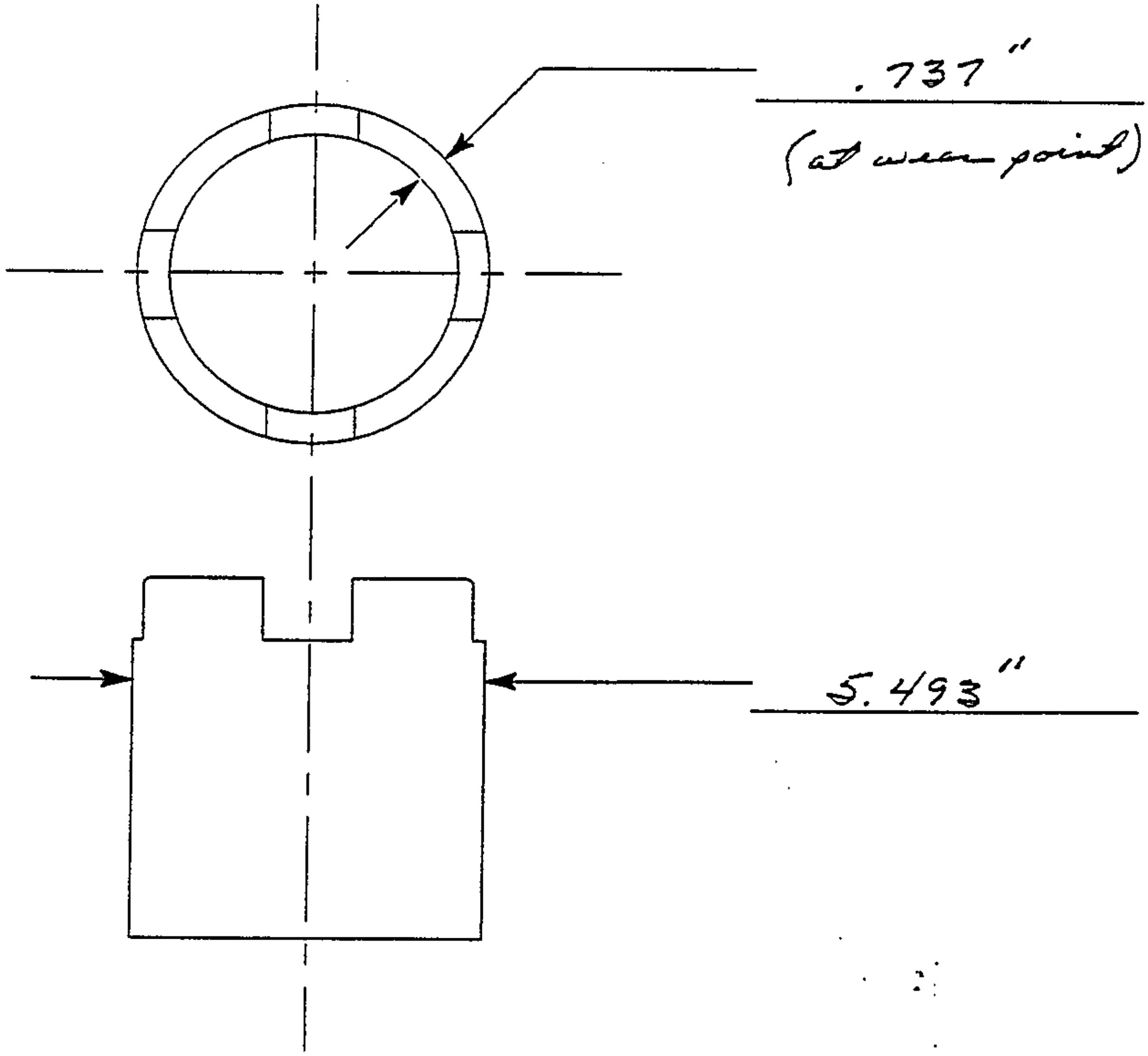

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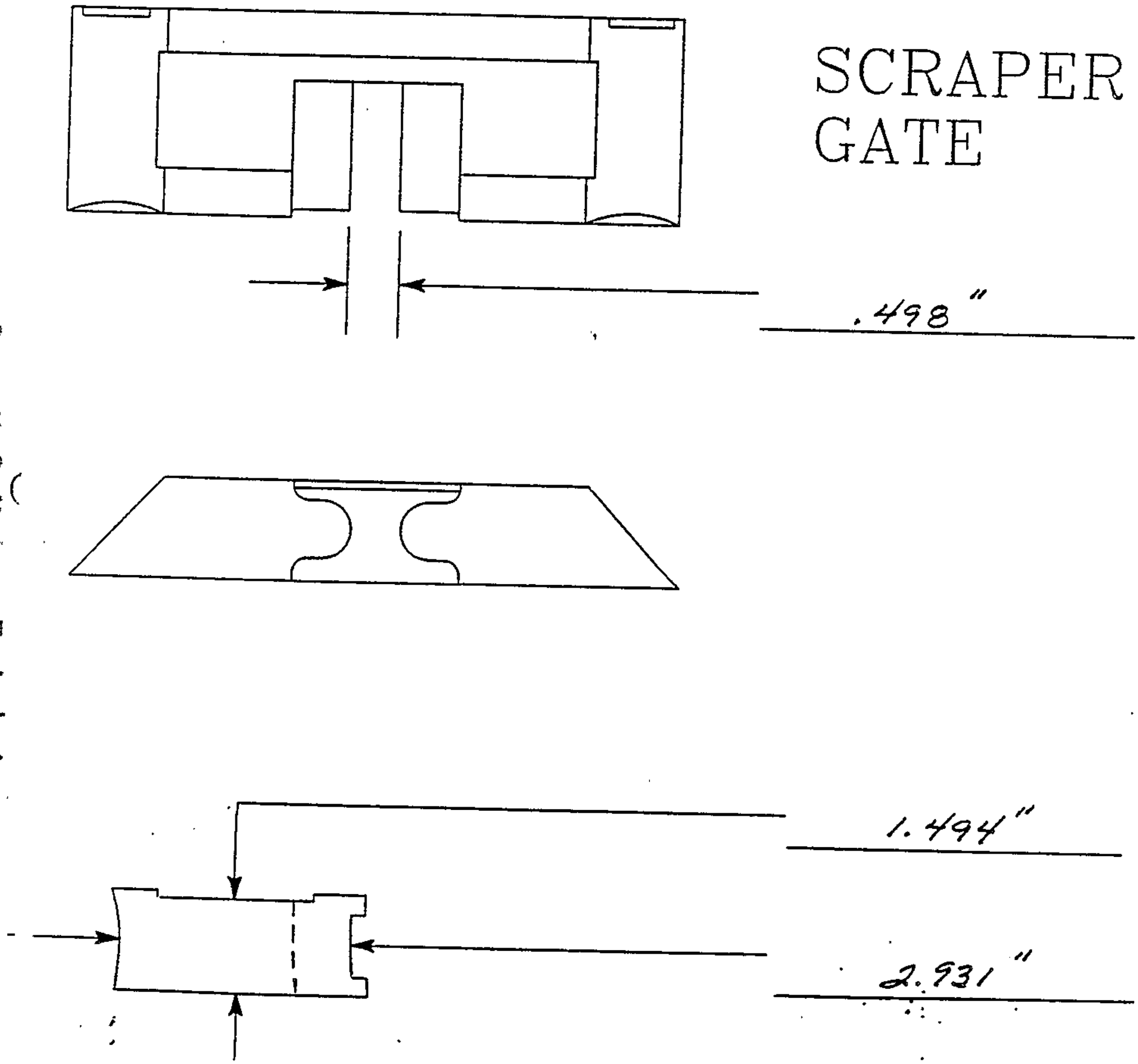

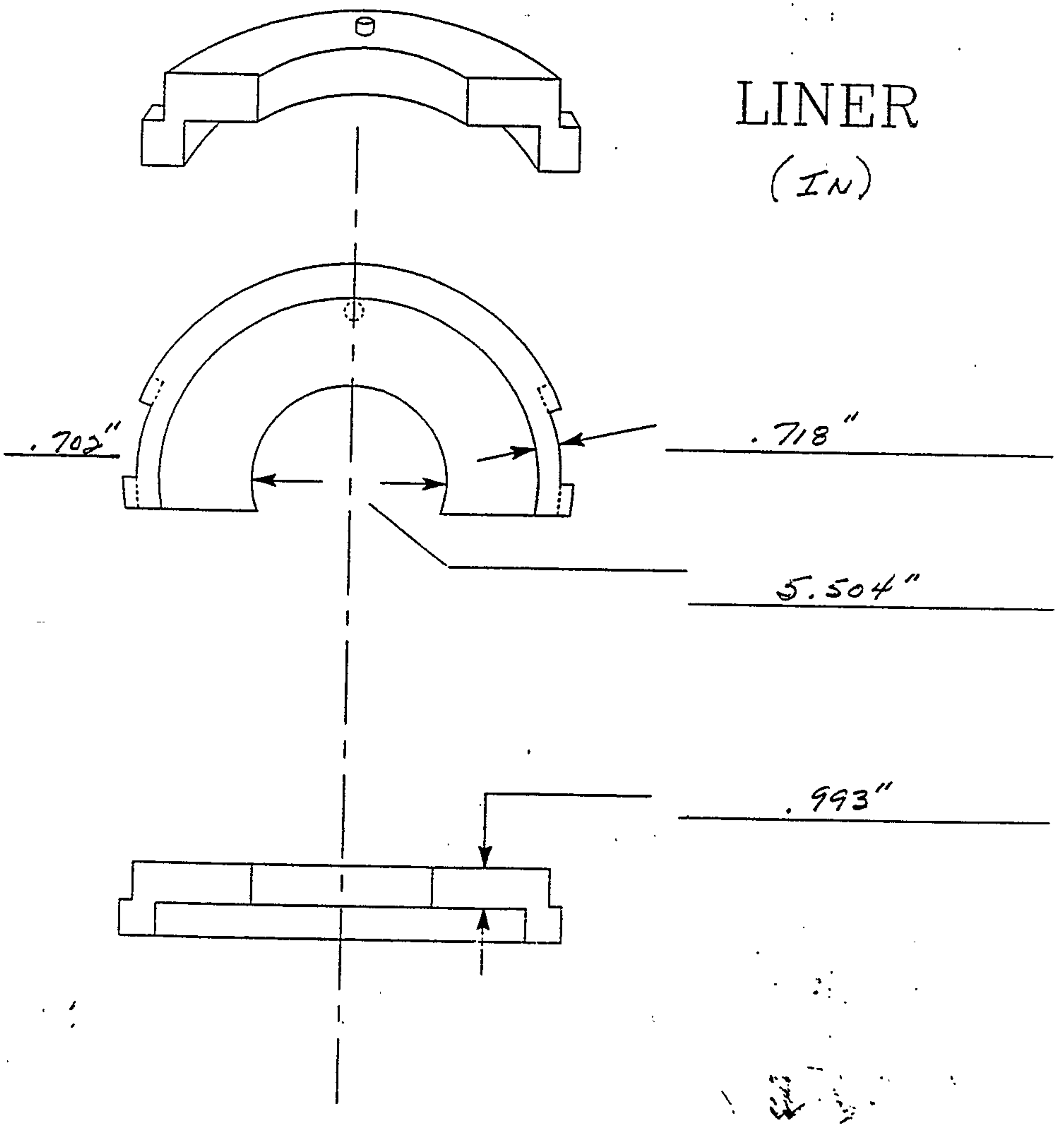

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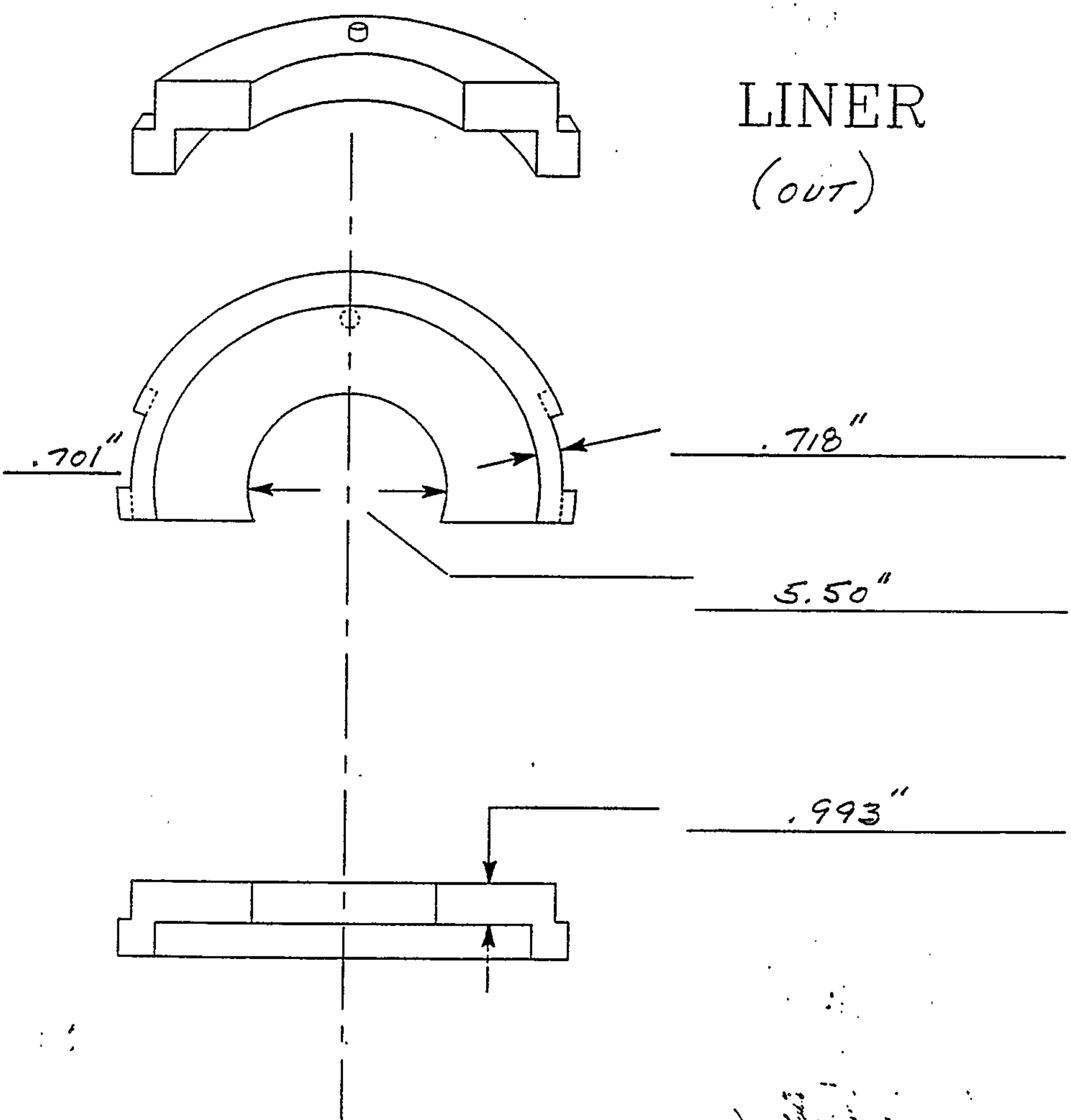
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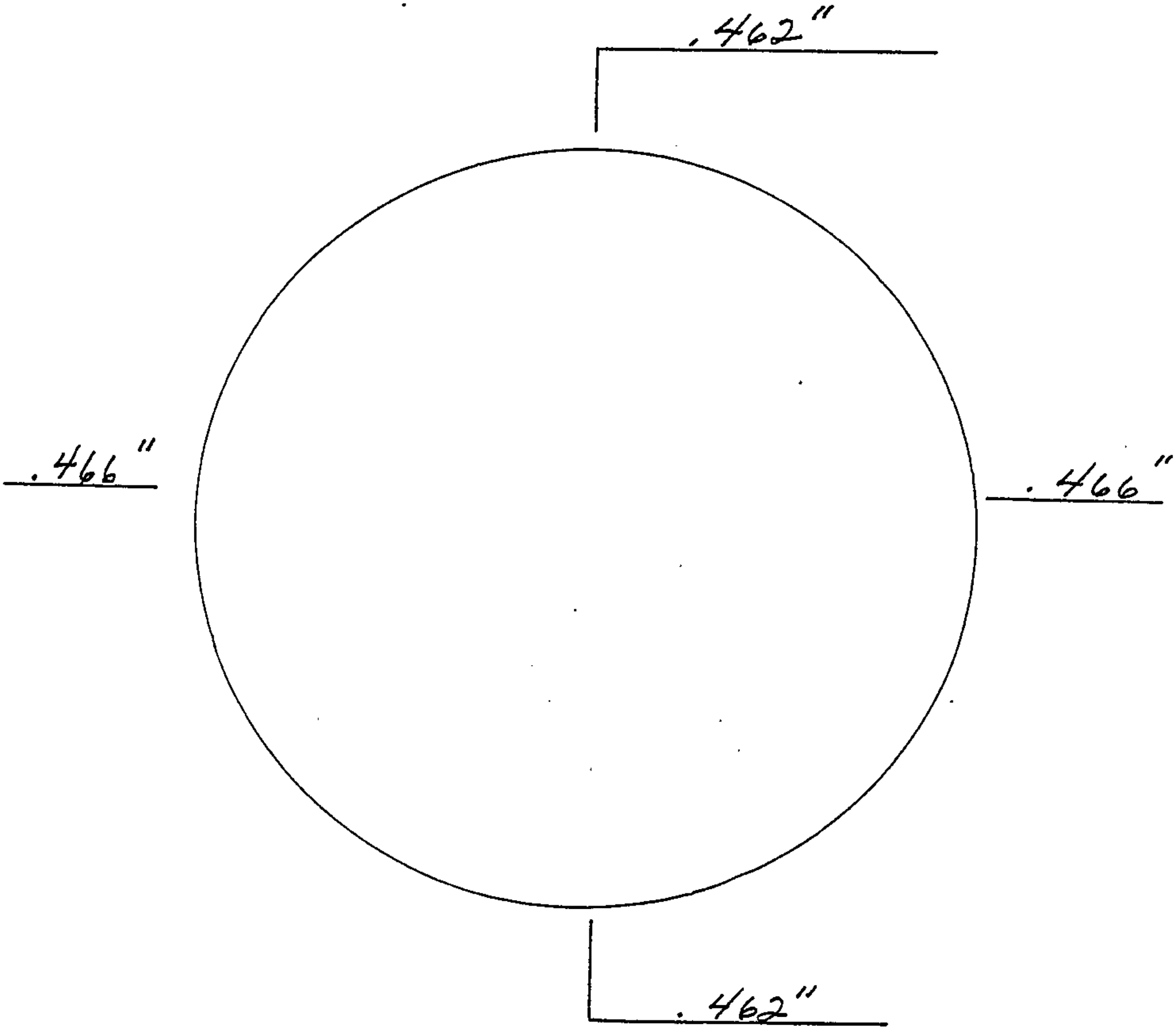

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ADDENDUM

It should be **NOTED** that on Tuesday morning, September 4, 1990, it was discovered that several phases of the subject test were run with the scrapergate inserted backwards in the pump.

The engineering department at SINE Pump was contacted immediately with inquiry as to what effects, if any, this incorrect part placement might have upon pump performance and test results obtained.

Immediately following is a copy of a letter provided by SINE Pump detailing the effects of improper part orientation.

SINE PUMP
DIVISION OF THE KONTRO COMPANY, INC.

TELEPHONE (508) 544-8011
TELEX 92-8431
FAX (508) 544-8000

500 WEST RIVER STREET P.O. BOX 240 ORANGE, MA 01364

September 4, 1990

Mr. Bob Fowler
Beckwith & Kuffel
East Washington
302 Torbett, Suite #224
Richland, WA 99354

Dear Mr. Fowler,

Sine Pump wishes to share our experience from lab tests and field applications in regards to the proper orientation of the Sine Pump scrapergate.

The scrapergate component of the Sine Pump is marked with a (SL) or (SR) to ensure the proper orientation of suction left of suction right. The design of the scrapergate and the scrapergate guide, also marked in the same manner, offers maximum performance when orientation is in relation to the suction port of the Sine Pump as viewed from the front cover.

The Sine Pump will operate if the scrapergate orientation is incorrect, however, when transferring a water-like product, a 10-20% performance loss may occur. This is most apparent when discharge pressures are present.

When transferring viscous products above 200 cps, performance loss is most often negligible and may not be visible in loss of flow or pressure capabilities.

The Sine Pump will operate in the reverse direction without damage to internal software components or power end bearings. If an application requires reverse operation or a Sine Pump is operated with the scrapergate oriented incorrectly and performance loss is noticed, simply change the scrapergate and guide to match the suction port from the front view and resume operation.

We hope this will help to troubleshoot the Sine Pump in your existing and future applications. Always feel free to contact our sales engineering department or technical service department with any questions.

Sincerely,

SINE PUMP

Frank Goulet

Frank Goulet
Sales Engineer

FG/llb

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